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TENTH SESSION

LONDON : 22 JUNE-1 JULY 1925.

GENERAL PROCEEDINGS

2nd Section : LOCOMOTIVES AND ROLLING STOCK

INAUGURAL MEETING

23 June 1925 (morning).

PROVISIONAL PRESIDENT : Mr. MARCHAL,

VICE-PRESIDENT OF THE PERMANENT COMMISSION OF THE ASSOCIATION.

The President (in French). — The Permanent Commission has instructed me to hold an inaugural meeting of the 2nd section and to ask you to accept as President Mr. WEISS, engineer in chief of traction of the Swiss Federal Railways. Mr. WEISS is wellknown to us by his numerous scientific works and by his active collaboration in past Congresses; he is a reporter on a question of great present day interest, namely, high speed electric locomotives.

Switzerland is a country without coal, but possessing a large number of waterfalls which its engineers have made admirable use of, especially as regards railway electrification, and in this class of work Mr. WEISS possesses special qualifications.

The Permanent Commission also suggests to you, as Principal Secretary, Mr. MINSART, principal engineer of the Belgian State Railways.

If the meeting is in agreement with the proposals which I have just had the honour to make, I will appoint Messrs. WEISS and MINSART to their respective offices. (*Applause.*)

I will therefore ask Messrs. WEISS and

MINSART to take their places. It would be well to then proceed with the nomination and installation of the vice-presidents.

Messrs. WEISS and MINSART took their places on the platform.

Mr. Weiss (in French). — Gentlemen, I must deeply thank Mr. MARCHAL for the very kind remarks he has just made, and I must thank you for the honour which you have done to my country in appointing me as President of this section.

I will do my best to carry out these important duties to the best of my ability, but I would ask you, however, to extend to me your indulgence, because I find some difficulty in expressing myself in French and even more so in English. I hope therefore that through the kind aid of our Principal Secretary and the translators it will be possible for me to do myself understand and to follow the debates.

We have in the first place to proceed to the nomination of the vice-presidents. I would propose for these positions :

Mr. A. FABRIS, chief running and rolling stock engineer of the Italian State Railways;

Mr. H. N. GRESLEY, C. B. E., chief mechanical engineer, London & North Eastern Railway;

Mr. HEROLD, chief of the Railway Department of the Swiss Federal Railway Board,

and Mr. LACOIN, engineer in chief of rolling stock and motive power of the Paris-Orleans Railway Company.

(*Signs of approval and applause.*)

— The section, on the proposal of the President, then completed the Secretariat and drew up a provisional agenda.

— The meeting terminated at 10.15 a.m.

[621 .133 & 621 .137.1]

QUESTION IV-A.

REDUCTION OF THE COST OF TRACTION : FUEL AND ITS COMBUSTION.

a) *Choice of fuel : coal, mixing of coals, peat, oil fuel, pulverised fuel, mixing of solid and liquid fuels (colloidal fuel);*

b) *Apparatus for the combustion of solid fuel (rocking-grates, etc.), liquid and pulverised fuels;*

c) *Mechanical stokers;*

d) *Smoke consumption. Spark arresters.*

Preliminary documents.

1st report (America), by Mr. G. H. Emerson. (See English edition of the *Bulletin*, November 1924, p. 1029, or separate issue [with red cover] No. 8.)

2nd report (British Empire), by Mr. C. B. Collett. (See English edition of the *Bulletin*, March 1925, p. 797, or separate issue [with red cover] No. 29.)

3rd report (other countries), by Mr. H. Chenu. (See English edition of the *Bulletin*, May 1925 [2nd part], p. 1783, or separate issue [with red cover] No. 45.)

Special reporter : Mr. G. H. Emerson. (See English edition of the *Bulletin*, June 1925, p. 2104.)

DISCUSSION BY THE SECTION

Meeting held on the 23 June 1925 (morning).

Mr. WEISS, in the chair.

— The meeting opened at 10 1/4 a. m.

The President (in French). — Before opening the discussion I think it may be useful to remind delegates that the official languages of the Congress are French and English. I would draw the attention of members of the section to the fact that some of the delegates have only an imperfect acquaintance with these two languages, and for this reason I would request the Special Reporters and any dele-

gates who take part in the discussion to be so good as to speak slowly and distinctly. All speakers are requested, further, before addressing the meeting, to indicate their number in the list of delegates, as well as the country and railway which they represent.

The programme of the 2nd section comprises the following questions :

1) Reduction of the cost of traction;

a) Fuel and its combustion (three reports);

b) Lubrication of axleboxes for all rolling stock (three reports);

2) High speed electric locomotives (two reports);

3) Arrangement of locomotive sheds (to be discussed with section I — three reports);

4) Fixed signals on the line (to be discussed with section III — four reports).

We have, therefore, a total of fifteen reports to consider; for this we have seven days at our disposal, or an average of a day and a half for each full question before us.

We shall thus have to work assiduously avoiding long speeches and endeavouring to express ourselves as clearly and briefly as possible.

With your permission we will now begin our examination of question IV-A (Reduction of the cost of traction : fuel and its combustion).

We have to deal with three reports, presented by Mr. Emerson, Mr. Chenu and Mr. Collett.

As Mr. Emerson is not present at this meeting I will ask Mr. Minsart, *Principal Secretary*, to read to us the summary of his report.

Mr. Minsart read the summary in French.

Mr. Bulleid, *Secretary of Section*, read Mr. Emerson's special report in English (1).

The President (in French). — If no one has any remarks to make upon the report which has just been read, I will ask Mr. Chenu to give a summary of his report.

Mr. Chenu, *Reporter* (in French). — My instructions were to report on the question now before us in respect of all countries with the exception of the United States and the British Empire.

The railways consulted as to the choice of fuel and the methods of purchase adopted may be divided into two main categories. Those in the first category buy for preference according to origin, subject to certain other secondary considerations. The others, on the contrary, stipulate that the fuels supplied to them shall satisfy a large number of very precise conditions, such as : percentage of ash, volatile matter, moisture, fusibility of ash, etc.

It is necessary therefore, in the first place to ascertain whether one or the other of these methods possesses any particular advantages.

Those who favour the first method (choice according to source) object to the second method on the grounds that it limits the market, restricts buying possibilities and, consequently, indirectly increases the net cost. If, however, one considers, as a typical instance, a railway which is clearly dependent for economic or political reasons on one particular mining district, it must be admitted that,

(1) See *Bulletin of Railway Congress*, June 1925, p. 2104.

although such a railway has always to order and receive the same fuels, it cannot afford to neglect to impose conditions regulating the following three main points : size, percentage of ash, percentage of moisture. It is difficult to see how it could be otherwise. Most mines screen their coals, and affix different values to the various classes thus obtained. It is essential that the purchaser on a large scale should protect himself against a supplier who might at any time be tempted to avoid meeting his obligations.

As regards the percentage of ash, it must be understood that a railway which always derives its supplies from a given mine will not necessarily always obtain an unvarying class of fuel. The nature of the coal deposits may vary; certain layers may be struck which may be of such a nature as to modify considerably the percentage of ash in the coal obtained. Screening and washing operations may be carried out more or less efficiently.

As regards the percentage of moisture, the water contents compose an unprofitable element entailing additionnal transport. There is, therefore, every reason for reducing the percentage to as low a figure as possible.

It would appear, therefore, that it is essential to lay down conditions relative to the composition of the fuel (percentage of ash and moisture) in all cases, and to verify the observance of these conditions when the fuel is delivered.

The second system of purchasing fuel adds to the above three conditions numerous other conditions dealing with the percentage of volatile matter, percentage of sulphur, fusibility of ash, friability and caking capacity.

Everybody knows how important these conditions are from the point of view of combustion. There is every reason why purchasers of coal, and in particular railway companies, should study the influence of these conditions on the life of fireboxes and on the efficiency of combustion, so that as exact an idea as possible may be formed as to the limits conducive to maximum output.

The conditions relative to the percentage of volatile matter are very important. From the replies received, however, it appears that most railway companies adopt very wide limits for the percentage of volatile matter. It is well known however, that a large amount of heat is lost owing to incomplete combustion. This loss of heat may vary from twenty to thirty per cent, and these figures show the importance, from the point of view of economy, of ascertaining definitely the most suitable percentage of volatile matter.

From what we have just said it would appear desirable to fix the percentage of volatile matter in each individual case. This appears to us of the utmost importance.

It would seem desirable, further that purchasers in the first category should also lay down a condition with regard to the percentage of volatile matter (*i. e.*, when fuel is purchased according to place of origin). They would thus define much more exactly the nature and quality of the coal which they wished to obtain, In this way, also, other mining areas would become aware of the special characteristics of the supplies required, and thus, if any modification occurred in commercial or economic conditions, competing mining areas would be in a position to supply immediately a coal answering to all the requirements.

Certain railways, in addition to laying down the conditions referred to above, also make stipulations relative to the calorific value of the coals supplied. These additional conditions would, however, appear superfluous, provided the other

conditions are definitely imposed. The calorific value, moreover, is only very relative.

Other railways adopt additional conditions with regard to evaporative capacity, measured in terms of kilograms of steam produced per kilogram of coal. These conditions can have no practical value. It is well known, of course, that the quantity of water vaporised per unit weight of coal depends on a very large number of factors which have no connection with the nature of the fuel, *e. g.*, type of firebox, system of combustion, firing, steam pressure, cleanliness of the boiler, type of grate, and, finally, the efficiency of the firemen. Further, determination of evaporative capacity becomes extraordinarily difficult when it is a case of a locomotive working under ordinary service conditions, as in the latter case all sorts of outside influences are encountered which have no connection with the locomotive itself, such as weather conditions, surface of the line, load. Finally, the results obtained in experiments upon such a locomotive can only be very approximate.

We will now consider the question of organisation of the fuel reception service.

The organisation of this service is very variable on different railways, and appears to be dependent on purely local considerations. It is not possible to deduce any general rule from the replies received. It appears, however, desirable to note that the essential point to be clearly specified in the regulations and supply contracts is the method which must be adopted in the taking of samples, their preparation and analysis. The results recorded in the replies which have reached us are very varied, this variation apparently being due rather to the methods adopted for the taking of samples than to the analyses themselves.

The fuel laboratory of a railway must be equipped in such a manner as to be in a position to ascertain whether the fuel supplied answers to the conditions enumerated above. It should possess not only a stationary boiler, but wherever possible a stationary testing locomotive. It should further be equipped with adequate apparatus for measuring the exact calorific value of the fuel. The boiler is not intended for testing the fuel as received, but is used for studying the influence of numerous factors connected with the process of combustion; it provides the means for carrying out series of tests with a view to ascertaining the law of variation of boiler output according to the variation of the factors of combustion : draught, depth of fire, frequency of firing, types of grate (free surface and dimensions); dimensions of arches and deflectors; metal used for firebox, tubes, etc.

In addition, the testing apparatus should be adequate for testing thouroughly; prior to testing on running locomotives, any apparatus or new system designed to improve the output of fireboxes or boilers, such as new types of grates, doors, smoke-consuming devices, cleaning appliances, tube blowers, apparatus for injecting auxiliary fuel, etc.

Finally, the fixed boiler provides a means of determining the characteristics which a fuel must possess if it is to meet the requirements of a given system of combustion. In this connection it will determine the most favourable characteristics of fuel according to the types of locomotives in use on a railway, with a view to obtaining the maximum output. It will not be used to ascertain the value of fuel « after supply », but will determine « before supply » what conditions must be complied with by the suppliers.

All railways are agreed that the fuel

used must be judged according to results obtained under actual working conditions by drivers and inspector-drivers. This additional check has the advantage that it is carried out by those employees who have the greatest interest in obtaining the best fuel, *i. e.* drivers.

As regards the method of purchase and the fixing of prices, present-day conditions in the various markets are such that there are no uniform rules, or even approximately general rules. From the replies received it is impossible to arrive at any general statement.

It may be interesting, however, to note that certain railways, and in particular most of the French railways and the Belgian State Railways, adopt a variable scale of prices depending on the percentage of moisture and of ash. This seems reasonable, since it is not possible to obtain dry coal and therefore the effective weight of the coal depends on the percentage of moisture.

As regards the ash content, this plays an even more pernicious role in combustion than does the moisture content. The total loss resulting from the presence of ash consists in : increased cost of transport; increased cost of handling; handling of the ash; loss through incomplete combustion; loss of heat contained in the ash. Apart from these disadvantages, the ash hinders combustion and considerably reduces the output of fireboxes; it reduces the length of journeys which can be effected without prolonged stops (with a consequent diminution of effective locomotive output); and, finally, it increases the chances of locomotives being short of steam.

Most of the railways which stipulate the percentage of ash apply penalties or premiums for each unit per cent of ash in excess of or below the standard figures, the amounts varying from 1 1/2 to 2 1/2 % of the basic price of the fuel.

Most railways mix the different classes of coal at their disposal, so as to obtain a mixture which in all its characteristics represents the desired type of fuel.

Certain railways merely make the desired mixture as and when required; others have special mixing apparatus installed at special centres. Such apparatus appears to produce a mixture which is more homogeneous and reliable than mixtures prepared by hand.

The question to be decided first of all as regards mixing centres is where these centres should be placed. Sometimes the mixing is done at each engine depot, but certain railway companies prefer to centralise the mixing operations at central depots from which the mixed coal is delivered to the various secondary depots.

At first sight the former procedure would appear the more satisfactory, as it should tend to reduce the net cost of handling the coal and loading on tender to a minimum. In the mixing centres the handling does not appear to be reduced; and in addition there are increased costs of transport, but it may be said in favour of such centres that they produce a mixture of more constant quality. It is essential to be able to procure sufficient quantities of coal from a number of different sources so that it may always be possible to produce the standard mixture desired.

The size of stocks varies from railway to railway, and depends above all on the distance from the mining districts and the size of the railway. The stock on hand at any given time is never less than the equivalent of one month's consumption.

The question has been raised as to the most suitable geographical situation for the central stores. This question is only of importance when there are central

mixing depots, in which case the location should be such that transport costs are reduced as much as possible.

Companies have been questioned also with regard to net costs. Tables are given in the statistical section of the report, but it must be said that examination of these tables does not suggest any conclusions of practical interest. The units adopted differ considerably. Certain railways give the consumption in terms of train-kilometres, others adopt the locomotive-kilometre and others the ton-kilometre or the virtual ton-kilometre. It would appear, therefore, highly desirable that all companies should adopt a standardised form of statistics which would permit of comparison between the different railways, and which would reveal the existence of any important factors affecting the question of coal consumption.

Not having received any suggestions in this respect, I venture to put forward my own.

It is difficult to arrive at any standardised form of statistics, because the coal consumption on the various railways is dependent on a very large number of factors, such as geographical situation, climate, surface of the lines, gauge, timetables, rolling stock, etc., etc. It would be necessary, therefore, in the first place to determine the influence of these different factors, so as to allow for them as accurately as possible in the statistical tables.

It does not seem possible, however, to arrive at any hard and fast solution of the problem, and it would appear that quite satisfactory results could be obtained if all railways recorded their consumption in terms of the « virtual ton-kilometre ». It would, in this case, be essential to determine exactly what is understood by the term « virtual ton-kilometre », and in particular it would be necessary to define the following points :

1. *Tonnage.* — Should this be determined by the weight of the train alone, or the combined weight of the train and locomotive?

2. *Passenger trains.* — On what method would the « ton hauled » be determined?

3. *Curves.* — On what formula would the resistance due to curves be determined?

4. *Up-grades and down-grades.*

5. *Stops and speed restrictions.*

6. *Speed.*

7. *Timetables.*

8. *Heating of passenger trains.*

9. *Climate, winds,* etc.

These factors are so numerous that it is useless to endeavour to take account of them all in defining the virtual ton-kilometre. It would appear necessary, therefore, for us to limit ourselves to taking into account a certain number only of these factors, namely the more important ones, such as grades, curves, speed, etc.

It appears premature at the present stage to put forward precise propositions, and the most that we can do is to express the hope that railways will take a resolute step forward on the lines suggested above and will adopt the virtual ton-kilometre as the standard unit. If this step is generally adopted, the choice of a common and clearly defined unit of work may eventually be attempted.

I will now turn to the question of fire-box grates.

The grates most generally used are either fixed grates or rocking grates.

The former are made of cast-iron or wrought-iron. I have no particular innovation to report in this connection : the advantages and disadvantages of the respective systems are well-known. The general opinion of the railways consulted appears, however, to favour rocking grates.

As regards fireboxes, their general form and dimensions depend on the nature of the fuel used. The great majority of fireboxes in use are either Belpaire or round-topped. It is impossible to conclude from the replies received which of the two types is the more widely preferred. The Belpaire firebox has in its favour the advantages presented by the formation of the crown and the method of staying, but a disadvantage is the complication presented by the manner of its connection with the boiler shell. The round topped firebox is more easily fixed, and is the most suitable type for large overhanging fireboxes.

The Eastern Railway of France, the Paris-Lyons-Mediterranean Railway, the Paris-Orleans Railway and the Tunisian Railway Company report a decided preference for the Belpaire firebox. The French State Railways state that they are unable to express an opinion, and the Belgian State Railways state that they prefer the round topped type for large overhanging fireboxes. None of the other railways express an opinion.

As regards the metal used in the construction of fireboxes, copper is most widely favoured.

No railway has used liquid fuel in locomotives on any large scale. This type of fuel has sometimes been used in particular cases such as shunting locomotives, running through tunnels, or as auxiliary fuel. Trials have also been carried out in certain cases where solid fuel was very dear.

The results obtained are as follows :

French State Railways : 1 t. of mazout = 2 t. of coal.

Paris-Lyons-Mediterranean : 1 t. of mazout = 1 t. 13 to 1.65 t. of coal.

Paris-Orleans : 1 t. of mazout = 1 t. 7 of coal.

Swiss Federal Railways : 1 t. of mazout = 1 t. 54 of coal.

These results are somewhat varied, but they serve to show at any rate that at the present day firing by means of liquid fuel costs in Europe at least twice as much as firing with coal.

However this may be, the advantages of firing by means of liquid fuel, as shown by the replies received, may be summarised as follows :

1. — Greater rapidity in getting up steam;

2. — Increase in the evaporative capacity of the locomotive;

3. — Easier handling;

4. — Reduction of the work of the fireman, making it possible to develop higher power;

5. — Liquid fuel is well adapted for intermittent firing;

6. — Liquid fuel is useful as an auxiliary fuel.

Tests carried out with pulverised fuels have been less numerous and less extensive than the tests carried out with liquid fuel.

The Swedish State Railways have experimented with pulverised peat, subsequently replacing the peat by pulverised coal. The results were not favourable.

The Netherlands State Railways have also carried out tests, but they state that they are not yet in a position to offer an opinion.

In Switzerland the tests have not given favourable results, but the authorities

make the reservation that the lack of success may be attributable to the fact that the coal used contained a very small proportion of volatile matter.

One serious objection to the use of pulverised fuel is the fact that it necessitates the installation of apparatus which is expensive to construct. In order to form an exact idea as to the validity of this objection, it would be necessary to carry out tests with pulverised coal on a larger scale.

The advantages generally recognised as regards the system of firing with pulverised fuel are :

1. — Possibility of using fuel of inferior quality;

2. — Increased output as a result of complete combustion and reduction of the quantity of unburnt matter in the ash;

3. — Better superheating;

4. — As the air required for combustion does not have to pass through a thick layer of solid fuel, the draught can be reduced, with a consequent reduction of the back-pressure in the cylinders;

5. — Ease and rapidity of getting up steam;

6. — Greater elasticity in fire control; the quantity of fuel to be burnt per unit of time can be regulated instantly as required, thus avoiding loss of steam through the safety valves during stops or on down-grades, a loss which is commonly compensated for by frequently opening the firedoor;

7. — Reduction of the work of the firemen; making it possible to develop high power with a single fireman.

None of the railways consulted has so far made use of mechanical stokers.

Several railways have used smoke consuming devices. The effectiveness of these devices is not clearly established. although the Swiss Federal Railways and the Java State Railways consider them entirely satisfactory from the point of view of the degree of smoke consumption attained. All the other railways express a certain doubt on the matter. This divergence of opinion is due probably to the difficulty of measuring the amount of smoke. However this may be, since this divergence of opinion exists, it may be concluded that the effectiveness of this apparatus is not self-evident, which is the sole condition aimed at.

The economy realised by the use of such apparatus seems equally doubtful. It cannot be denied, however, that a smoke-consuming device can only improve combustion and consequently must lead to a corresponding increase in boiler output.

The tests so far carried out with these devices have not been sufficiently extensive to enable us to decide as to their economic advantages, and to compare these avantages with the disadvantages and numerous sources of expense entailed by their use.

There is nothing of importance to be said as regards spark arresters. These devices consist of screens of wellknown types, fixed horizontally or diagonally, or of cones placed on the chimneys. These various forms may be used separately or together. They are made of perforated sheets, bars or metallic netting. The width of the openings varies from 4 to 11 mm. (5/32 to 7/16 inch).

No railway has given any indication as to the resistance to the draught presented by this apparatus. It must, however, cause additional resistance to the passage of the gases, and it is this reason, moreover, which induces drivers in certain cases to dismantle the apparatus when they are able to do this. In this connection it may be noticed that if the conical form of spark arrester is the lightest, the

most practical and the least costly, it is on the other hand easily taken down by the driver, a fact which constitutes a certain danger.

Spark arresters easily become blocked up, and it might be useful to ascertain the relative advantages of the various types solely from this point of view.

Mr. Bulleid then read in English a summary of Mr. Chenu's report.

The President (in French). — Mr. Collett, the third reporter, being absent, I will open the discussion on the two reports which have just been summarised for you.

As regards the choice of fuel, I would like to point out that Mr. Chenu has put forward in his report an interesting question regarding the standardisation of the net cost per virtual ton-kilometre. This is a point which the section might usefully discuss.

Mr. Lacoin, Paris-Orleans Railway (in French). — In order to arrive at a practical solution of the question put forward by Mr. Chenu, it would first of all be desirable to arrive at some definite idea as to the economy effected by the firemen. I believe that Mr. Chenu's report states that certain railways have fixed the premiums paid to employees according to the consumption per virtual ton-kilometre. I see there are delegates from these railways present at this meeting. Perhaps they will give us their views on this point.

Mr. Diniz, Portuguese Railway Company (in French). — During the year 1924, I conducted a series of trials with a view to arriving at the expression of consumption in terms of the virtual ton-kilometre.

Starting from the formulæ of Mr. Mauduit, I calculated the virtual distances applicable to the different parts of our system. I arrived at coefficients varying from 1.2 for the level parts to 2.4 in the more difficult sections. For the whole system the coefficient worked out at 1.4.

A series of tests carried out with the same locomotive, the same staff and the same coal, at full pressure, first of all on the sections having a coefficient of 1.2 and afterwards on the sections with a coefficient of from 1.8 to 2.2, gave figures of effective consumption per kilometre in which the variation was as high as 73 %. Reducing the consumption to the virtual ton-kilometre basis, the difference fell to 2 %.

These results being considered satisfactory, I began, as from 1st January 1925, to compile my statistics on the virtual ton-kilometre basis, using them in calculating the premiums payable to drivers.

As far as I personally am concerned, having to serve practically the whole of my railway system by one type of locomotive, I am very much in favour of this method of calculation, which makes it possible to pay premiums to drivers on a basis which is approximately equitable whether you are dealing with the level or the montainous districts of the country.

Mr. Bianchi, Italian State Railways (in French). — The Italian State Railways also have for a long time past used similar calculations with a view to arriving at figures based on the total virtual ton hauled on each line and for each direction of traffic. It is on this basis that we calculate the amount of the premiums paid to drivers. This procedure has been in force for some thirty years and gives complete satisfaction.

We use a formula similar to that used for the traction and resistance of trains. Account is taken in particular of grades

and curves, but no allowance is made for speed.

Our formula appears to me a very practical one.

Sir Henry Fowler, London Midland & Scottish Railway. — Mr. President, I am glad to think that after the discussion we had at Rome we are starting really at the basis of all questions of cost, that is to say, what is actually meant by the virtual ton-mile? You may remember that we suggested that this should be one of the subjects that might very well be discussed, I believe, we proposed by a small committee. That was the suggestion that we made at Rome, but it has never been acted upon in this country, and I believe it has never been acted upon in America.

We should be glad of any information with regard to how allowance is made for the gradient. If the gradient is one in a thousand, do you simply calculate upon the amount to which your load is lifted? If so, what is the allowance which is made when on the level and the line is straight, because, in spite of what our friend from the Italian State Railways has said just now, the resistance varies so very greatly with the speed. The speed is undoubtedly a very great factor in the tractive effort required upon a straight level line. I have never seen any figures which went closely into detail with regard to the increase of tractive effort owing to curves. There again it must depend a certain extent upon how the road is laid — that is to say, how much allowance is made for the fact that you are on a radius rather than on a straight road and the gauge may vary — and, in addition to that, the speed on which you go round the curve has a decided effect.

The suggestion, as I say, has previously been made that this should be one of the subjects put down for discussion or for investigation by the Congress, and I know that any information we receive would be of the greatest interest and assistance to us.

The President (in French). — Could not some delegate give the exact formula adopted by his administration? Several methods exist of determining the virtual length of lines.

M. Diniz (in French). — As I have just stated, the formula which we use is that contained in the report presented to the Higher Council of French Public Works by the Committee appointed under the decision of 14th November 1918 to investigate the question of the electrification of railways of general public utility; this report was drawn up by Mr. Mauduit, Professor of the Faculty of Science and of the Electrotechnical Institute, Nancy. This formula comprises a coefficient for curves and another for down-grades.

Sir Henry Fowler. — Might I ask whether these are formulæ which are used on other railways? It is not on your own railways, Sir, perhaps more than on any other that the question of gradient is important? Do you use the formulæ of Professor Mauduit in Switzerland?

The President (in French). — Formulæ of this nature are not used in Switzerland for arriving at the consumption of coal, but exclusively in connection with preliminary investigations with a view to the construction of new lines or the modification of existing lines. I am not in a position to give you exact details, but I believe that the formula used by us is the Lindner formula which was used in connection with the construction of the St. Gothard line.

Sir Henry Fowler. — I wish to ask whether the formulæ are used generally or whether they are only used by the Italian State Railways. There are many systems which use the virtual ton-kilometre, but do they all use the same formulæ?

The President (in French). — I do not think so.

Sir Henry Fowler. — That is really the point.

Mr. Pawlowski, Polish State Railways (in French). — The Polish State Railways have a very level surface in the north of the country, and a more varied surface in the south. They have studied the question of the determination of virtual length so as to be in a position to express engine output and fuel costs in terms of one and the same unit. I think that by the time of the next Congress we shall be in a position to supply some definite data.

The investigations which we are making are very important, and the results will appear in the journal *L'Ingénieur des Chemins de fer,* published in Warsaw.

The President (in French). — The report states that trials with colloidal fuel have not as yet led to any conclusive results. As far as I personally am concerned, I have never heard them mentioned. Might I ask the American delegates whether any progress has been reported since the report was prepared.

The same applies to the question of liquid fuel. Some years ago a large number of tests were carried out with liquid fuel principally in England. From the information received by us, however, it does not appear that it has so far been regularly used. Is any further information forthcoming in this connection?

Mr. Cantuniar, Roumanian State Railways (in French). — The Roumanian railways use liquid fuel extensively. Before the war tests were carried out with oil only. The trials lasted for some five years, but the results were not satisfactory in view of the rapid deterioration of the fireboxes. The engines were converted by taking out the grates and putting in a complete brick arch, but the boilers were not modified in any way.

As the results were not satisfactory, we then tried mixed combustion, that is to say, we used at the same time and in the same firebox a solid fuel (lignite, abundant supplies of which exist in the country, buth which does not give more than 6 300 British thermal units per lb. mixed with mazout, the mixture giving a heat value of approximately 18 000 British thermal units per lb.). The prescribed proportions were half lignite and half oil, but the drivers objected to these proportions. The liquid fuel is easier to use, and the drivers had a tendency to use more liquid fuel than solid fuel, so that by degrees we arrived, on the Roumanian railways, at a mixture consisting of 2 kgr. of oil to 1 kgr. of solid fuel. These figures apply for both passenger trains and goods trains.

The arrangement of the firebox is very simple. A grate is installed, just as in fireboxes intended for the burning of coal, and at the back of the boiler under the firebox door there is an opening for the introduction of the oil sprayer. The flame is projected against the lower part of the arch below the smoke tubes; it goes round the arch and reaches half-way between the tube plate and the back plate of the firebox. It has not, therefore, been possible to obtain a continuous flame; the tip of the flame turns back below the arch.

The old exhaust arrangements were in-

sufficient to give a suitable draught, and it was necessary to add a bar to improve the draught.

As regards the sprayer, the report states that the design adopted is of little importance provided it is strong and easily cleaned whenever necessary.

Our experience, which covers a period of 25 years, has taught us that the choice of the design of the sprayer is of great importance. We have used both internal and external sprayers, and have arrived at the following conclusions :

The external sprayer is the more simple, it gives a very intense sheet of flame and it causes no noise in the driver's cab.

The internal sprayer is very noisy, the flame cannot burn to its proper length because of the speed of the spray which, on leaving the sprayer, is greater than the speed of propagation of the flame.

The consumption of steam — with the aid of which the spraying takes place — is less with the internal sprayer, and for this reason, although this sprayer makes a great deal of noise, it has been accepted without question by the drivers.

The exclusive use of liquid fuel does not appear to us to be practicable until a sprayer has been evolved which will give a small flame when required. The existing types can only produce flames when a somewhat high rate of consumption has been reached. It is highly desirable to be able to reduce the size of the flame during stops and on down-grades.

This is also one reason why the Roumanian railways have been unable to use oil only, in spite of its higher efficiency, and have been compelled to resort to mixed combustion.

The solid fuel used is generally of mediocre quality; but the layer of fuel on the grate has no other object than to maintain the heating during stops, and to prevent cold air from entering directly into the firebox.

The flow to the sprayer is regulated by the fireman by means of a throttle. This is not a scientific system, as it is not satisfactory to leave it to the fireman to regulate the flow, which has a very direct influence on the consumption. What is wanted is a sprayer with fixed proportions for oil and steam. Up to the present such a type is not forthcoming.

Only when the various questions to which I have referred have been solved, do I think we shall find that the use of liquid fuel will have become a practical possibility.

The economic side of the question as it affects Roumania, is as follows : The solid fuel obtainable in the country itself works out at 1 000 lei (approximately £1) per ton; liquid fuel costs us (1 500 lei (30/-) per ton; but, as the solid fuel at our disposal can only be relied upon to give 6 300 British thermal units per lb. whereas the liquid fuel gives 18 000 British thermal units per lb. it must be agreed that, so far as this country is concerned, it is more advantageous to use liquid fuel.

The oil supplies are plentiful. Before the war the residues left after distillation were in little demand, but this is no longer the case and orders from abroad are plentiful. This is a further reason why the use of mixed combustion with solid fuel of mediocre quality, is favoured by our administration for passenger trains. Coal only is often used for goods trains.

Mr. Nobili, Italian State Railways (in French). — Some years ago we carried out in Italy some very exhaustive trials with liquid fuel. As the cost of transport greatly affects the net cost of solid fuel in

Italy (this fuel being brought from abroad), this consideration is of very great importance.

Here are the principal results of these trials :

From the point of view of output, the use of liquid fuel only is to be recommended, contrary to the opinion of the Roumanian State Railway delegate.

I emphasize the fact that I am now regarding the question exclusively from the point of view of output.

As regards the installation of this system of heating on locomotives, we found that it was preferable, from the point of view of output, to place the burners in the back part of the firebox so as to give the flame a greater effective path.

As regards the question of deterioration of the firebox, our experience of this system has not been sufficiently long to enable us to form any definite conclusions. We are, however, under the impression that, with the lining which we have fitted inside the firebox, this question is not of the first importance.

Mr. Cantuniar (in French). — I am entirely in agreement — as I have indeed pointed out — with the theory that the use of liquid fuel only gives a better output than the use of solid fuel and liquid fuel combined. The combustion of oil can only take place provided there is a sufficient supply of air, and it may be that the air available after that used for consumption of the coal is not sufficient in quantity. My remarks only referred to the preservation of the firebox, and in view of the high temperature developed, deterioration will always be more rapid with liquid fuel.

Mr. Nobili (in French). — I would point out that, with a view to avoiding excessive temperatures, we have installed as many as four burners in one firebox. When the locomotive is not running at its normal speed, the firebox is only fed by two burners. We have thus been able to avoid damage to the tube plates through excessive temperatures.

The President (in French). — I think we might now pass on to points *b*), *c*) and *d*) — (Equipment for burning fuels: mechanical stokers and smoke-consuming devices).

Mr. Pawlowski (in French). — I would like to draw the attention of the section to the following points :

In the three reports little is said of the question of getting rid of clinkers. Mr. Emerson, in his report, refers briefly to rocking grates, but he does not say whether their use is to be recommended. The point is, however, of great importance for countries which consume coal of medium or poor quality. This coal may contain from 8 to 20 % of clinker, and the degree of facility with which fireboxes can be cleared from it greatly affects their output.

The drop grate is widely used in Europe, the most popular type being the « Titan ». Can any delegates give us information about the effectiveness of these two systems?

Col. Collins, South African Railways and Harbours. — I think the question asked was whether the drop grates are the best means of getting rid of clinker and ash. The whole of the engines on the South African Railways, which burn coal with a very high percentage of ash, are fitted with rocking grates and drop grates. It is quite easy and a comparatively simple matter to get rid of the clinker and ash with a drop grate.

Mr. E. W. Head, Ceylon Government Railway. — On the Ceylon Government Railway a number of engines are fitted with rocking grates and drop grates; and during the last year or so, a somewhat inferior quality of coal with a very large percentage of ash and clinker has been in use. The rocking and drop grates have proved entirely successful; and they have been found to be of considerable assistance in cleaning of fires at the stopping stages on the heavy gradient sections of the line.

The President (in French). — Little is said in the reports on the question of mechanical stokers. They are, however, in use in several countries, apart from the United States. It would appear, from the remarks which have been made, that smoke-consuming devices are not particularly popular. These forms of apparatus are somewhat expensive, both as regards initial cost and cost of upkeep. I consider that we should be very guarded in expressing an opinion as to their effectiveness. The essential point seems to be not so much the intrinsic value of the apparatus, as the manner in which the firemen are taught to use it. For example, in England, so far as I have had an opportunity of ascertaining, locomotives are not fitted with these devices, but they emit very little smoke, thanks to the efficiency of the firemen. Smoke-consuming devices were formerly much used in Belgium. It appears that this country has now reverted to more simple systems.

In Switzerland also the original types of apparatus have gradually been considerably modified and simplified. As far as I personally am concerned, I am not very satisfied with the practical results of these forms of apparatus, which only work perfectly provided the firemen devote the necessary care to the heating.

— The meeting was adjourned at 12.5 p. m.

* * *

— The meeting re-opened at 2.30 p. m. under the chairmanship of Mr. Weiss.

The President (in French). — Before entering upon the question of lubrication, I think it would be useful if some of the delegates could give us additional information regarding fuel and combustion. The American delegates, also, might perhaps give us particulars of their experience of the use of mechanical stokers.

Mr. D. F. Crawford, Department of State, United States of America. — Mr. President, unfortunately I was unable to be present this morning when the subject of mechanical stokers was before the section, but I can give you in a few moments the results of experience in the United States. At the present time there are about 8 000 locomotives in service equipped with mechanical stokers of several different designs. The earliest stokers have been in service since perhaps 1912; the larger number have been in service since 1914 and the number largely augmented again in 1918. Stokers have been applied generally to the larger locomotives. Of the total number of locomotives in the United States, something over 15 % are equipped with stokers. Stokers, however, are applied to perhaps 90 % of the locomotives having a tractive effort of 60 000 lb., or over. Many stokers are applied to locomotives having 45 square feet of grate, the larger number, of course, being applied to locomotives having larger grates.

The results have been sufficiently satisfactory for the railways to continue their application as locomotives are built.

It is quite safe to say that except where oil is used for firing, all locomotives of over 60 000 lb. tractive effort are now being equipped with the mechanical stoker. One of the reasons for using the mechanical stoker in the United States is due to the fact that locomotives have reached a size where a second fireman has from time to time been requested. The mechanical stoker, taking the place of the second fireman, has prevented the additional labor.

We have generally found that with the stoker the temperature of the fire has been increased as compared with hand firing. It is possible to carry a thinner fire and to increase the length of engine runs, some of the trains operating over two or even three divisions without stopping the engine to clean the fire. In many cases — perhaps in all cases — it has been possible to augment the tonnage hauled by the locomotive from 10 to 15 %. On one railroad of which I have knowledge, the tonnage is 15 % above hand firing.

It has also been possible, perhaps in the majority of cases, to enlarge the blast pipe nozzle, thus reducing the back pressure and obtaining good results thereby. The stokers on the locomotives have gone through a matter of 10 or 12 years of development and are now sufficiently sturdy to require comparatively small repairs, and they run from shopping to shopping of the locomotives for general overhauling. From time to time there is trouble with stokers due to foreign matter, but most of the stokers built now are sufficiently robust to overcome this without serious damage to the stokers.

The smaller locomotives — locomotives with under 40 square feet of grate area — have had stokers applied to them largely in parts of the United States where the summer temperature is such that it makes it difficult for the fireman to handle the firing and therefore the stoker has been applied. I think it will be found that the possibility of using a uniform steam pressure is a decided advantage. I shall be glad to answer any question if so desired.

Mr. Lacoin (in French). — Could Mr. Crawford tell us what economy is effected by having a mechanical stoker on a locomotive which can be fired by a single fireman?

Mr. Crawford. — Of course, the stoker in itself cannot in any way effect economy of coal. It is merely a device for moving the coal from the tender into the firebox. Therefore, the only way in which it can effect, and does in some cases effect economy is by maintaining a more even fire due to a more constant supply of coal. The fact that the firedoor remains closed prevents a reduction in temperature of the fire from time to time, such as occurs, of course, when the firedoor is opened for hand firing. The evaporation obtained with the stoker being above that which a fireman can obtain, indicates an equal or better economy. Of course, the stoker cannot in any way change the character of the fuel — the amount of heat in the fuel — and therefore its promise of economy is only in supplying a small amount of coal at a time and keeping the firedoor closed.

Sir Henry Fowler. — Mr. Crawford has raised the question of the fire being hotter. I would like to know whether that has any effect, and if so what effect, upon the super-heat. We found when we used oil fuel, as we did on the railroad of which I used to be Chief Mechanical Engineer, that we increased our super-heat by 150° Fahr., getting frequently a temperature of 800° Fahr. for our steam. The result was unfortunate, because our

white metal packing rings were not right in composition to withstand this increased temperature. But knowing, as one does, the great advantage from an economical standpoint that you get with the turbine engine with high super-heat, we feel that had we been able at the time to go on with such a high temperature for our steam, we should have added very considerably to the economy that we were getting by the use of super-heated steam. I would be glad to know whether anything which has happened in the States has shown that they are getting a greater economy by obtaining a greater amount of super-heat.

I would also like to know what is the effect with regard to smoke. I remember a well-known professor of locomotive engineering saying that the prosperity of the United States was directly proportional to the density of smoke issuing from their locomotive chimneys. I know, too, that there was much trouble in many cities with regard to smoke, and I should like to know whether the mechanical stoker has been able to reduce that smoke.

Mr. H. N. Gresley, London & North Eastern Railway. — I should like to ask Mr. Crawford a question with regard to the stoker and the use of stokers in America. I take it that the reason why they are used so largely is because with the very large locomotives and the very great combustion of coal in such engines they have more coal burnt than one man can put on. I understand from Mr. Crawford that there is no economy claimed for the stoker in coal consumption. What is really regarded as being the limit in number of pounds of coal per hour which one man will put on satisfactorily in a locomotive? In other words, when do you come to the time when you consider it desirable to have a stoker because one man is incapable of firing the engine? I do not want to know how many pounds of coal per mile; the real thing is the number of pounds of coal per hour that the man is required to put on.

Mr. D. F. Crawford. — To answer Sir Henry Fowler's question first, I unfortunately have not a large amount of data on the subject; but on one series of tests where I had the privilege of looking over the results obtained, there was an increase in the amount of super-heat. I do not remember the exact amount, but there was a noticeable increase. The increase in fire temperature was decidedly noticeable.

As to smoke, many years ago we resorted to what we call « one shovel » firing, that is, the fireman puts in a small amount of coal at a time rather than a larger amount and holding the door open.

As to the means of obtaining economy and reducing smoke, as a general proposition, most of the stokers in service put in a small quantity of coal — 5 or 6 lb. at a time — repeating this very quickly. By this means the smoke is somewhat reduced. By careful supervision of the smoke in cities, the complaint that Sir Henry Fowler referred to has been largely reduced, but that has been accomplished both with the hand-firing and with the stoker by careful manipulation.

To answer Mr. Gresley's question as to the maximum amount that a fireman can handle, in the United States I should say that we should regard it rather from the point of view of what the man will handle that what he can handle. I personally supervised tests where a man on a number of runs handled 7 000 lb. of coal per hour; but that was under careful supervision and with considerable effort. As a matter of fact, we

ıve assumed that after a locomotive eaches a size and a loading where a man as to handle in the neighborhood of 000 lb. of coal per hour for, say, four ours or over, he will not do much more ıan that. I should say that the majority f stokers that have been applied to loco- ıotives in the United States, have been ɔplied to locomotives that would require ı the neighborhood of 4 000 lb. per hour more. There are a number of stokers, owever, in the southwestern part of the tates where I should say that 3 000 lb. would be a nearer figure, due to the higher atmospheric temperature.

As to coal economy, as I said before, the stoker, of course, does nothing but put the coal in. It simply takes the place of the man, and with equally careful regulation by the man, the advantage of higher temperature, less back pressure, a closed door and a thinner fire would give economy if we would take it as economy. But in the States we do not; we take it as additional power or take it as better running.

Meeting of 24 June 1925 (morning).

Mr. WEISS, IN THE CHAIR.

The President (in French). — Before pening the discussion on question IV-B, will ask Mr. Chenu, the Reporter on uestion IV-A to read to us the summary hich he has prepared.

Mr. Chenu, *Reporter* (in French). — *hoice of fuel, coal. — Mixtures of coal.* The choice of fuel depends essentially n the sources of supply at the disposal f the railways. Whatever the nature of ıe fuel chosen, the railways have the reatest reason to determine prior to or- ering — and to verify on delivery — the haracteristics of the fuel, these charac- eristics being such as will give the ma- imum firebox output under the various ystems of firing in use on the particular ailway.

As regards solid fuel, the difficulty ex- erienced in many cases in maintaining ıpplies, the specified characteristics of hich remain constant, makes it neces- ary to mix different kinds of fuel in ertain definite proportions and with the reatest care. For this purpose it appears advisable to use mechanical mixing apparatus, installed either at the sheds themselves or at a number of mixing centres.

The statistics prepared by railways with regard to fuel consumption are not capable of comparison among themselves, as the units adopted differ considerably.

Standardised statistics would be of great value for all railways. It scarcely appears possible to effect this reform immediately, but it seems probable that there will be a gradual tendency in the right direction if railways would express their fuel consumption in terms of the virtual ton-kilometre.

If a sufficiently large number of railways decided to adopt this system, it would then be possible to discover an exact and standardised definition of the virtual ton-kilometre.

Sir Henry Fowler. — Do you wish for remarks as we go along?

The President. — Certainly.

Sir Henry Fowler. — I think instead of « possible » it should be « desirable ». I think we should say that it would be desirable that a standardisation of the virtual ton-kilometre should take place.

Mr. Chenu (in French). — The text would then read : « It scarcely appears possible to effect this reform immediately, but it is desirable that there should be a gradual tendency... etc. »

Mr. Lacoin (in French). — Is it not premature to adopt this attitude? I personally think it would be preferable to express the hope that the question will be studied with a view to ascertaining in what measure the establishment of a formula determining exactly the virtual ton-kilometre would make it possible to prepare standardised statistics.

Mr. Nobili (in French). — The Italian railways have used this unit as the basis of their statistics for more than 20 years. The result has been very satisfactory and enables us to say that there is no doubt whatever that it is desirable to institute standardised statistics on this basis.

Mr. Lacoin (in French). — It may be that reasons other than those connected with statistics led the Italian railways to adopt the virtual ton-kilometre, for example, the fixing of premiums payable to drivers. I do not think, however, that the experience of the Italian railways necessarily proves that other railways ought to change their procedure, because these other railways also obtain excellent results, without basing their statistics on the virtual ton-kilometre.

The President (in French). — It is open to us to express a desire to see this statistical unit adopted. Nobody is obliged to share our views.

Mr. Lacoin (in French). — Would it not be possible to make the text less emphatic, by using the word « desirable »?

Mr. Chenu (in French). — The text would then read : « It scarcely appears possible to effect this reform immediately, but it is desirable that there should be a gradual tendency... etc. » (*Signs of approval.*)

The President (in French). — Are you agreed as to this wording?

Sir Henry Fowler. — I am rather doubtful whether it would not be better that the English text should read : that the virtual ton-mile (or kilometre) would seem to be, with our present knowledge, the better standard. It is just the English text that I am thinking of.

The President (in French). — Yes, that is the real translation.

Sir Henry Fowler. — It would seem to be the better unit of comparison; I think that is the English phrase.

The President (in French). — That is just what Mr. Chenu has said in French.

Sir Henry Fowler. — I just wanted to get the English text correct.

Mr. Chenu (in French). — *Liquid fuel.* — Fuel oil is used when, taking into account its calorific value and purchase price, the net cost per calorie thus produced is comparable with the net cost obtaining in the case of solid fuel. It is, therefore, only used by railways which, on the one hand, are near to oil fields and, on the other, are at a distance from coal fields or can only procure solid fuel of inferior quality.

When the cost of oil fuel is such that it can be used, its use has many advantages, the chief being : reduction of the

quantity of fuel used when standing; easily regulated firing on hilly sections; increase in the power of the locomotive; less work for the fireman; easier handling; better control of smoke.

Pulverised fuels. Colloidal fuel. — These fuels have up to the present only been used experimentally by certain railways.

Equipment for burning solid fuels. Grates. — There appears to be a tendency on most railways to use rocking grates instead of fixed grates.

Mr. H. N. Gresley. — That is not correct, I think, so far as England is concerned. Rocking grates are not used at all in this country. I think the wording is a great deal too drastic. It may be that in some places there is a tendency towards increasing the use of rocking grates, but it is not universal.

Sir Henry Fowler. — It will read correctly in the text if it is stated that the use of rocking grates is increasing. That may mean that one country is not using them at all.

Mr. Vallantin, Paris-Lyons-Mediterranean Railway (in French). — We have on our system about 800 locomotives fitted with rocking grates, but we are removing these grates gradually as we have found that they increase the consumption of coal and are more costly to maintain than ordinary grates. It is therefore desirable to modify the text proposed.

Mr. Chenu (in French). — Here is a new version :

« There appears to be a tendency to use rocking grates on railways which have long distance runs and which can only procure fuel of moderate quality. » *(Signs of disapproval.)*

Mr. H. N. Gresley. — No, that is not so.

The President (in French). — It would perhaps be better to leave this clause out altogether.

Sir Henry Fowler. — May I suggest that if you wish to put in anything, we should say that there is no uniformity of opinion with regard to the advantages of the use of rocking grates.

Mr. Gresley. — There is no advantage whatever in putting that in.

Sir Henry Fowler. — Except that it shows that there is a difference of opinion. Our American friends have not spoken : I think that they would speak very strongly the other way. With all due respect, judging by Mr. Chenu's paper, practically speaking at all events, the majority of the French and Belgian lines say that they use rocking grates for large fireboxes and for engines which have to run long journeys, especially where they have to use an inferior class of fuel. I think that sums up what has been said, judging by what I remember of Mr. Chenu's paper when I was dealing with it.

Mr. G. G. Elliott, South African Railways and Harbours. — In the early days, when we had to use our South African coals which were very poor and contained a large percentage of ash and clinker, we had to introduce the rocking finger bars and drop grates with spaces between the bars sufficiently wide to pass the ashes to the ash pan and allow sufficient air to get to the choked coal. Before this we used Welsh coal which being much more free of ash and clinker burnt quite well on the ordinary straight bars with narrow air spaces.

During the transition period we used the two coals mixed but the more inflammable Welsh coal dropped alight into

the ash pan and created a fire underneath the cast iron bars which melted them and brought about many total engine failures.

For this reason it would not be possible, nor is it necessary, to have finger bars and drop grates for Welsh coal or coal of equivalent quality and properties, which have been designated for coals of high ash and clinker content.

The President (in French). — I think that after all it will be better to delete altogether this passage in Mr. Chenu's text.

Mr. Chenu (in French). — *Mechanical stokers.* — The fitting of mechanical stokers has made possible the use of locomotives burning continuously more coal than can be fired by any fireman. The use of mechanical stokers appears justified when the coal consumption is from 1 500 to 2 000 kgr. (3 300 to 4 400 lb.) per hour. Their economic value, from the point of view of firebox output, has not been clearly determined. They give, however, a higher superheat temperature than in the case of hand firing.

Mr. Duchatel, Eastern Railway, France (in French). — I am not sure whether it is desirable to include this statement regarding super-heat. The increase of super-heat may result from an increased consumption of coal; it does not necessarily follow that the mere substitution of mechanical stoking for hand firing can give a greater super-heat.

Mr. Chenu (in French). — In hand firing the opening of the fire door is more frequent in proportion as the consumption of coal increases.

Mr. Duchatel (in French). — None the less, I propose that we make no reference to super-heat in the summary.

Mr. Vallantin (in French). — The summary states that the use of mechanical stokers becomes advisable when the coal consumption is from 1 500 to 2 000 kgr. per hour. On our system we have locomotives burning 1 500 kgr. per hour, for which we have not found it necessary to use mechanical stokers. We ought to be very careful about what we say in our summary, as it may get into the hands of the trade unions and be used as a lever to impose mechanical stokers.

Mr. Bachellery, Midi Railway of France (in French). — I agree with Mr. Vallantin that it is preferable not to quote any figures, as these might be used against us at a later date. We should confine ourselves to a more general statement.

Mr. Haynes, Canadian National Railways. — I consider that, in a country like Canada, where trains are heavy, the ruling grades high, the runs long and the climate severe in the winter time, it is indispensable that the road-engines be equipped with « mechanical stokers ».

It is not unusual, in severe weather, on the North-Western part Canada, where blizzards are of frequent occurrence, for the thermometer to register as low as —45° Fahr. The call for steam, on the boiler of the large engines is then inordinate and sustained for hours. The fire-box of the boiler must be tight to the access of superfluous glacial air from the outside. The mechanical stoker, *properly designed and operated*, will cut all influx of air from the fire-box door which can be kept shut tight; in contrast with what is bound to take place in the case of the « one shovel firing ». The fire-box will thus be kept hotter and the fire will be free from the chilling action of the cold drafts, the tubes will also be exempt from any strains or local contraction, and thereby, leakage causing delays, and even the stalling of trains,

etc. The trend of progress is towards heavy engines. In the United States and to a degree in Canada, some of our new engines have reached up to a tractive force of 60 000 lb., in some exceptional cases, the 100 000 lb. goal has been reached. These engines require heavy boilers, large grates, which can only be fed properly with solid fuel, through some mechanical means.

Mr. Chenu (in French). — Here is a new wording, proposed by the President : « The mechanical stoker enables a higher and more uniform temperature to be maintained in the firebox. »

The President (in French). — Mr. Vallantin and Mr. Bachellery propose, further, the omission of any figure relative to the limit at which the use of mechanical stokers becomes desirable.

Mr. Gresley. — That seems to be rather too conclusive. If we adopt the resolution which has just been read out, in effect it says that by the use of mechanical stokers you have a more uniform and a hotter fire, and therefore it is better. I can see no reason, therefore, why we should not all use mechanical stokers straight away, if that be the case. But surely there are some disadvantages. What you want to have is uniformity of heat and uniformity of fire, and you want to get the hottest fire. I submit that there has been no direct evidence brought before us that those things are attained by mechanical stokers. In fact we know from tests which have been carried out that very carefully hand-fired locomotives can run more economically than locomotives which have been fired by mechanical stokers, and I think it is too definite to say as a general conclusion that the use of mechanical stokers produces greater heat and more uniformity.

Mr. Haynes. — The mechanical stoker is a new and costly accessory to the tender. There are not more than a few models at present on the market. But, considering the increase in size of the locomotive boiler — the contrivance « has come to stay » — and will ultimately be perfected. A good fireman is a rarity, and the « one shovel firing » can no more cope with the requirements in fuel of a forced boiler. Now, as to the proper time to instal a stoker — one must rely on the limit — of endurance or efficiency of the manual stoker.

Mr. Bachellery (in French). — I think that the principal idea of the wording which the President has just read out is one upon which everybody is agreed, namely, that the mechanical stoker's main advantage is that it prevents the frequent opening of the firebox door. This idea might be stated more precisely by saying: « An advantage in favour of mechanical stokers is that they do away with the necessity of frequent opening of the firebox door. »

Sir Henry Fowler. — May I suggest that the text should be : « Where the quantity of coal is such that it is difficult to fire it by hand, there are advantages in mechanical firing, which also does away with the necessity for opening the firehole door. »

The President (in French). — Gentlemen, I propose for your acceptance the wording which has just been put forward, and which covers the points which have arisen during the discussion.

Mr. Chenu (in French). — *Smoke consuming devices.* — The efficiency of these devices and the economy that they give are not definitely known; on many railways the tendency appears to be to remove them.

Spark arresters. — Spark arresters, fitted either in the smoke box or on the chimney, and constructed of grids, perforated plates, wire mesh or expanded metal, are used by all railways and give satisfaction.

Mr. Gresley. — I cannot agree with that conclusion. It would be a very serious thing for us in England. In England we find no necessity to use spark arresters at all. In fact, I have some thousands of locomotives fitted with spark arresters, and on that particular section of the railway where these locomotives are working we have more fires than we have on other sections of the line; and I am taking them all off. I have said this in court, because we have had many cases where people have claimed for damages owing to fires. To have a resolution like that passed by this assembly would be most damaging to the railway companies in England. We could not possibly agree to that, because we fit our locomotives with appliances which we consider reduce as far as possible the emission of sparks, and with careful firing there is no necessity to have any sparks emitted; but that resolution would bind us to fit spark arresters, because it is too definitely worded. You must have an exemption.

Sir Henry Fowler. — I would like to endorse what Mr. Gresley has said. I have personally carried out many experiments, and I find that any spark arrester which will prevent fires will also prevent the engine steaming properly. I have in my office in a little bottle some sparks which I have taken in the United States through some of the spark arresters which have been referred to, in the presence of a gentleman who is here today. Those sparks are of very large size, and would cause very great damage. I wish to endorse all that Mr. Gresley has said, and to say, too, that if the engine is to be efficient, you must not have a spark arrester.

Mr. Chenu (in French). — A suggested amended wording is as follows : « Spark arresters are generally constructed of grids, perforated plates, wire mesh or expanded metal. The necessity of their use for avoiding the emission of sparks is strongly questioned. »

Col. Collins. — Most Colonial railways are forced by law to fix spark arresters, and I do not think the meeting should pass that. I do not think it would be right, in dealing with spark arresters, to say that there is a doubt as to their efficiency, because it is possible to fit spark arresters which will break up the sparks or the cinders to such a size that the danger of fire is reduced to a minimum.

Sir Henry Fowler. — If I may say so, to Col. Collins, this is strongly contested : it is contested by Mr. Gresley and by myself, and I think by every other British locomotive engineer; and that is all that we have put down in the summary, namely that it is strongly contested. We wish to say that we very strongly contest it, and would prefer to have even another adjective in front of that if we could work one in.

The President (in French). — There are other countries in which similar regulations are imposed. The Congress may, none the less, express the opinion that the utility of spark arresters is strongly contested.

Mr. Rivet, Ministry of Public Works, France (in French). — Could we not say that the efficiency of spark arresters as they exist today is contested? It may be, indeed, that better types will be evolved in the future. In France the use of spark

arresters is required by law. I propose, therefore, that we say that the utility of the existing types of spark arrester is contested, and that it is desirable that an endeavour should be made to produce a more suitable type.

Mr. Politis, Ministry of Communications, Greece (in French). — As the President has just said, certain countries, and Greece in particular, prescribe the use of spark arresters, and this regulation is necessary particularly in connection with insurance against fire. If we now stated that we considered these devices ineffective, the insurance companies might raise certain difficulties. I suggest, therefore, that we say that their efficacy is limited.

Mr. Chenu (in French). — We might perhaps say : « Their efficacy is contested; these devices are, however, in general use up to the present for preventing the emission of sparks. »

Mr. H. N. Gresley. — I cannot agree to that.

Sir Henry Fowler. — I wish to put forward another text : « The question of spark arresters is very complex » — I think that will meet with the agreement of everybody — « and no paragraph can be drawn up which will meet with the acceptance of all the delegates. »

Mr. Chenu (in French). — I suggest that we confine ourselves to the first half of the paragraph :

« Spark arresters are generally constructed of grids, perforated plates, wire mesh or expanded metal. »

The President (in French). — I think the section might accept this very restricted wording.

No further objection having been raised, I wish to express to Mr. Chenu the hearty thanks of the section for the work which he has accomplished on its behalf.

DISCUSSION AT THE GENERAL MEETING

Meeting held on the 27 June 1925 (morning).

PRESIDENT : THE RIGHT HON. VISCOUNT CHURCHILL.
GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. GHILAIN.

Sir Henry Fowler, *General Secretary*, read the final summary adopted by the 2nd section.

— This final summary gave rise to no comments.

The President. — The following are the clauses of the

Final summary.

« *Choice of fuel. Coals. Mixing of coals.*

« The choice of fuels is based essen- « tially on the source of supply at the « disposal of the railways. The type of « fuel chosen by the railways, before « ordering, should specify and, on deli- « very, verify the characteristics of the « fuel which should give the maximum « amount of efficiency in the boilers « under the conditions they are working.

« The statistics of coal consumption as « carried out at the present time do not « allow comparison between the various « administrations.

« Standard statistics would be of great « advantage for all railways. Such sta- « tistics cannot be prepared at once, but « a step towards them would be taken if « the coal consumption was based on the « virtual ton-kilometre.

« The difficulty concerning solid fuel « which one frequently meets is to get « supplies, whose characteristics, once « determined, have a constant value; the « necessity or the advantage which may « result from the purchase of different « coals; and, finally, the irregularity of « supplies of different coals necessitate « the mixing of coal scientifically and « thoroughly. To attain this effect it « seems to be advisable to use mechan- « ical means of mixing coal, which are « provided either at the running shed or « at different points of the system where « central mixing yards are installed.

« *Liquid fuel.*

« Liquid fuel is used when, taking into « account the purchase price, the calo- « rific value is about the same as with « solid fuel. It is therefore only used « by those lines which are near to the oil « fields and far from the coal fields or « where the solid fuel is of inferior qua- « lity.

« When the cost of oil fuel is such that « it can be used, its use has many advant- « ages, the chief being :

« *a*) Reduction of quantity of fuel « used when standing;

« *b*) Increase of power of the locomo- « tive;

« *c*) Less work for the fireman;

« *d*) Easily regulated firing on hilly « sections;

« *e*) More easily operated;

« *f*) Better control of smoke.

« *Pulverised and colloidal fuel.*

« These fuels have not got beyond the « experimental stage.

« *Equipment for burning fuels.*

« *Mechanical stokers.*

« When the quantity of coal is such « that it is difficult to fire it by hand, « there are advantages in mechanical « firing, which also does away with « the necessity for opening the firehole « door.

« *Smoke consuming devices.*

« The efficiency of these devices and « the economy that they give are not de- « finitely known; on many railways the « tendency appears to be to remove them.

« *Spark arresters.*

« Spark arresters are generally con- « structed of grids and perforated plates, « wire mesh or expanded metal. »

— The General Meeting ratified this final summary.

621 .135.2 & 625 .214]

QUESTION IV-B.

REDUCTION OF THE COST OF TRACTION : LUBRICATION OF AXLEBOXES FOR ALL ROLLING STOCK.

a) *Axleboxes. — Plain bearings. Roller and ball bearings;*

b) *Lubricants.*

Preliminary documents.

1st report (America), by Mr. G. H. EMERSON. (See English edition of the *Bulletin*, November 1924, p. 1055, or separate issue [with red cover] No. 9.)

2nd report (all countries, except America and the British Empire), by Mr. TÊTE. (See English edition of the *Bulletin*, April 1925, p. 859, or separate issue [with red cover] No. 30.)

3rd report (British Empire), by Sir Henry FOWLER. (See English edition of the *Bulletin*, February 1925, p. 313, or separate issue [with red cover] No. 18.)

Special reporter : Sir Henry FOWLER. (See English edition of the *Bulletin*, June 1925, p. 2107.)

DISCUSSION BY THE SECTION

Meeting held on the 23 June 1925 (afternoon).

Mr. M. WEISS, PRESIDENT, IN THE CHAIR.

The President (in French). — We will now deal with question IV-B : « Lubrication of axleboxes for all rolling stock ».

I will call upon Sir Henry Fowler to give us a summary of his special report.

Sir Henry Fowler read his special report, which was published in the June 1925 number of the *Bulletin of the Railway Congress*, p. 2107.

Mr. Tête, *Reporter* (in French). — The special report which has been prepared on the question of lubrication includes all the points which I wish to make, so that I have very little to add.

As the special reporter has very clearly emphasised, the special points which affect the behaviour of axleboxes depend upon local circumstances, such as climatic conditions, loads, distance run, etc.

To discuss all these circumstances in detail would take far too long, and I will confine myself to stating that most im-

portant of all it is necessary to avoid loss of oil through the back of the box at high speeds. I might remark that for this purpose certain administrations employ wool pads which prevent the oil being thrown out against the dust shield.

As regards the precautions to be taken to avoid hot boxes, the most important thing is to ensure that the bearings are properly bedded to the journals. I think in this connection I should mention the method used on the Belgian State Railways, which consists of running in the brasses on the journal. This method almost entirely obviates any risk of hot boxes.

The President (in French). — As Mr. Emerson is not present, I throw open the reports which have been presented for discussion.

Mr. Van Schouwenburg, Netherland Indian Railways Cy. — I should like to put the following questions on account of the experience which we have had on our railway. We have until now followed the general practice in Europe of oiling the axlebox bearing. Latterly we have gone over to the use of packing. This, I have heard, is very satisfactory. The reason we have done this is that our axleboxes lost a considerable amount of oil, which is prevented by using packing.

In the papers given here I find in the report of Mr. Tête that the average of axleboxes running hot is about 2 %, as he mentions in one case. On the other hand, I see in the report of Mr. Emerson that this percentage with axleboxes using packing is 97.94 %. This figure mentioned on page 1069 of the November 1924 number of the *Bulletin of the Railway Congress* seems to me somewhat alarming, and I should like to know what Mr. Emerson says.

Sir Henry Fowler. — Might I suggest that this is a misprint. I do not know if Mr. Wallis would confirm the figures here.

Mr. Wallis, Pennsylvania Railroad System. — I cannot express any opinion upon them.

The President (in French). — I also have found several misprints.

Mr. Tête (in French). — I have found a number of mistakes of this kind. Certain figures which have been sent in to me by the administrations were obviously wrong, and I have asked for these to be corrected. It may be that some of these errors have not been corrected.

Mr. Forte, Italian State Railways (in French). — We have found on the Italian Railways, after the war, very great differences in oil consumption. We have investigated this question so as to reduce the oil consumption as far as possible, as it is a matter of considerable expense.

We commenced by carrying out tests on tender axleboxes so as to ascertain how long a tender could run without it being necessary to renew the oil in the boxes. This test was carried out with a special oil, but the results obtained might be quite well applied to ordinary lubrication. We found that a bogie tender could run for more than ten months, that is to say, over 30 000 miles, without renewing the oil and without any hot boxes occurring.

We have followed this with a test upon engine axles. We have found that engines could run with packing in the underkeep with lubrication only once per month.

The test is not yet completed, but on the basis of the results we have laid down the following rules for the examination

of axleboxes : *Tenders*, once per six months; *engines*, once per fifteen days.

We have recently decided to extend the test to all the engines on a complete division, that is to say, about 500 engines. In order to avoid any influence which the quality of the packing employed might have on the results of our test, we used a carefully mixture of 40 % horsehair and 60 % wool, both being of the best quality.

The proportion of these two materials is of considerable importance.

We have also found that it is necessary to pay considerable attention to the way in which the packing is placed in the box. A badly packed box may lead to overheating. Me have found an economy of oil of nearly 90 % in the case of tenders.

Mr. Maunsell, Southern Railway, England. — Mr. President and Gentlemen, there is one point in connection with the construction of carriage and wagon axleboxes which I think has perhaps not been quite sufficiently emphasised in the summary of the paper which we have just heard and, as far as I have been able to gather, in the discussion which has followed.

It is, I believe, a matter of the utmost importance that sufficient provision should be made in axleboxes for the radiation or the conduction of heat which is developed between the journal and the bearing. Some short time ago I conducted a series of experiments in connection with this matter. One axlebox on which the test was made was of the type very usual in this country — the open fronted box cast in one piece in which it is not possible to machine the top of the box. The box was fitted in the ordinary way with a glut and a bearing; but although the glut was machined on both sides and the top of the bearing machined, still the surface between the top of the glut and the box was not complete — the surfaces were not wholly in contact. The temperatures were obtained by drilling holes at the ends of the brass and inserting clinical thermometers which were carefully watched. Two boxes on one carriage were of the type which I have described; another box was of a different pattern. In that box the top was machined, thereby ensuring perfect contact between the glut and the top of the box, and the results were certainly improved. The temperatures registered — not by one trial but by a series of trials extending over three months — showed that the temperature in the bearing in which the top of the box was machined was nearly 30° Fahr. lower than the temperature in the box in which the top of the box was rough as it came from the foundry, or slightly fitted — the rough lumps chipped off.

I think this points to the fact that no matter how careful we may be about the metal which is used in the bearing or the class of packing which is used or the lubricant which is used, the best results will not be obtained unless we make provision for the conduction of heat from the bearing to the outside of the box.

The President (in French). — Perhaps some of the delegates can give us some information as regards mechanical lubrication. In Mr. Tête's report, mention is made of the « isothermos » system, the use of which has extended considerably in France of late years.

Mention is also made in the reports of certain other systems of mechanical lubrication.

Mr. Lancrenon, Northern Railway, France (in French). — The Northern Railway of France has extended the test

which it commenced before the war with the « isothermos » axleboxes. On the 1 June 1924, 40 tenders and 52 bogie coaches were so fitted.

On the tenders the results have been very satisfactory. We have completely done away with lubrication carried out by the driver, who no longer has to attend to tender axleboxes before starting on a journey. The axleboxes are inspected monthly at the running shed. This leads to a considerable economy in oil and the number of hot boxes has decreased.

On the bogie coaching stock for express trains, the isothermos box has also given good results. As in the case of the tenders, the axleboxes are inspected every month or after running 9 300 miles. The consumption of oil per axlebox for this distance is about 56 drams.

We have chiefly fitted isothermos boxes to stock used on the Paris-Brussels non-stop service and have never had any trouble.

As a general rule, on each occasion that an isothermos box has run hot, we have found that the cause has been a mechanical defect. These failures have necessitated a certain number of alterations, but have not been due to any defects of the system itself.

As regards freight stock, the tests have not been carried so far. I might mention, however, that we are about to fit isothermos axleboxes on a series of 300 30-ton brake vans for freight trains. As these vehicles are always running with a full load, they are therefore more liable to hot boxes.

It must be well understood that the dust shield must be absolutely tight, as any defect in this respect will allow oil to escape and lead to trouble.

Mr. Poncet, Eastern Railway, France (in French). — The isothermos axleboxes have up to the present only been used for outside bearings. The Isothermos Company is getting out a scheme on behalf of the Eastern Railway to use these axleboxes on the inside bearings of bogies for engines of the *Pacific* type. These axleboxes are fitted with two dust shields and a special arrangement different from the ordinary axleboxes. If the test which is to be carried out by the Eastern Company is satisfactory, the use of the isothermos boxes might be considerably extended.

The President (in French). — Have tests been carried out with these axleboxes to determine the frictional resistance? Has one found any appreciable difference as compared with ordinary axleboxes and is this difference due to the large amount of oil delivered to the bearings?

Mr. Lancrenon (in French). — No tests have been carried out on this point, but it is probable that the question will be investigated. The lubrication of these boxes is very satisfactory; a disc throws the oil on to the top of the bearing, and turns at a speed proportional to the speed of the vehicle.

The President (in French). — For freight trains which run at slow speed, has no trouble been found from the use of these axleboxes?

Mr. Lancrenon (in French). — No, and I may quote the case of a vehicle which was fitted up as an experiment before the war and which ran throughout the whole period of the war without anything being done to the axleboxes. These were not inspected for several years, and all that was done was to add from time to time a small quantity of oil, and they continued to work perfectly.

I do not think therefore there is any reason why the isothermos system should not be applied to freight wagons.

The President (in French). — Have any delegates any information to offer as regards ball and roller bearing axleboxes?

It is stated in the reports that the first cost is very high and that the system is not to be recommended except for suburban trains or trains making frequent stops.

Mr. Lacoin, Paris-Orleans Railway (in French). — Tests have been made on suburban trains composed of ordinary rolling stock and of rolling stock fitted with ball bearing axleboxes.

Dynamometer tests have shown a reduction in the drawbar tractive effort of at least 7 to 8 % for speeds up to 50 miles per hour. The maximum economy is for speeds of 25 to 31 miles per hour, and is as much as 20 %. It has been found on the other hand that there is a very slight reduction in the work done by the engine in the case of trains which make frequent stops, where nearly all the energy goes to accelerate the train, while at high speeds the wind resistance has a preponderating effect.

We have considered that the cost of fitting roller or ball bearing axleboxes is too high, and that their use is only justified upon special rolling stock for high speeds, as for example, refrigerator vans which are attached to express trains.

The President (in French). — Do not the Swedish Railways use roller bearing axleboxes?

Mr. Ahlberg, Bergslagen Railway, Sweden. — We have done some experimental work on the Bergslagen Railway with roller and ball bearings. The ball bearings would not do; they cracked and we could not use them. The roller bearings are going very well but I am not sure that they are not too expensive. They cost too much and save too little. Sir Henry Fowler has spoken about the hammering action in the machinery of the locomotives and we have a hammering action, as to the carriages, on the wheels at every joint of the rails. This hammering action is working through the wheel, the axle and the box up to the spring. If you have a hard roller bearing between the axle and the box it works otherwise than the white metal bearing. We found in some cases that the tyres loosened because of the hammering. It is possible that the brakes may have helped to loosen the tyres, because when you have roller bearings and you are going down hill you have to use the brakes more than if you have the other bearings. These things have to be studied more before we, for our part, are willing to accept roller bearings.

Mr. Reid, London Midland & Scottish Railway. — Mr. President and Gentlemen, Sir Henry Fowler has reported that we have made a number of tests with the roller bearings, and I think the conclusions at which we have arrived are very similar to those that have been spoken of and discussed, namely, that there is very little advantage to be gained by the adoption of roller bearings, except possibly a little at starting. The starting problem is perhaps not quite so acute here as it is in America, where they have adopted roller bearings, I believe, with a view to easing the starting of the train.

With regard to the temperature of the axlebox, I was very interested in that subject, and intended to make some inquiries with regard to it, although I had not appreciated that the fitting of the slipper, or glut, would make such a

difference in the temperature of the bearing. In examining the axlebox of a train that has run 200 or 300 miles one generally finds that the leading side of the box is comparatively cool, and that in every case it is only the trailing side of the box, which is not exposed to the air, which shows any sign of heating. Personally I think that one important point is the degree of finish which is put on to the journal of the axle. In that connection it is the practice of the London Midland & Scottish Railway to grind the axles. We adopted that practice because it was expeditious and more economical in the first place than burnishing. The results which have been obtained from the ground axle have been extremely satisfactory, and tests have been made on passenger coaches running on express trains, half of the axles being fitted with burnished journals and the other axles having ground journals. It was found that the temperature was less with the ground journals than was the case with the burnished or roller finished journals.

I also noted in the papers a point that was mentioned as to the consumption of oil by axleboxes. I think that the consumption of oil is very largely governed by the amount that is used and the instructions on the line as to the frequency of oiling the boxes. On the Midland Railway, which is now part of the London Midland & Scottish Railway, for a number of years prior to amalgamation we made a practice on our freight stock of only oiling once in three months, and we found that by that means we very considerably reduced the quantity of oil used in an axlebox without incurring any increase in the number of hot journals. With the introduction of the common user of wagons in this country it became general to oil once a month.

There is one other point that I might mention, namely, as to the desirability of adopting either pad lubrication or waste lubrication throughout any administration. In this country there is a certain amount of difficulty owing to both methods being used. We find that with waste lubrication it is necessary to use an oil of higher viscosity, and that the thicker oil is not so suitable for pad lubrication. It would appear therefore that to attempt to use one oil for both pad and waste lubrication is not conducive to good results.

The question of white metal has been mentioned. In that connection we have had very excellent results from a white metal used with a fairly high proportion of lead. It is only when we come to heavy axle loads on express trains passenger stock where you want a greater margin of safety, that we think it necessary to use white metal containing a larger proportion of tin.

Mr. Gresley, London & North Eastern Railway. — With regard to locomotive bearings the principal troubles, that many of us have in England are with driving boxes — the coupled boxes on engines. So far as bogie boxes, tender boxes and carrying boxes generally are concerned, there should not be much trouble, and the best results are certainly obtained with bearings which have a tin base for the white metal. We have tried applying mechanical lubricators to axleboxes with considerable success and I have a large number of engines fitted with mechanical lubrication now. The only difficulty with mechanical lubricators is to get a pipe from the lubricator to the axlebox which will stand the vibration and the vertical movement. After a time some pipes get broken and then the advantages of the mechanical lubricator disappear. We test all lubricators before they are

applied to the engines, so that they will pump against a pressure of 200 lb. per square inch; in other words, we really get forced lubrication on to the axles. The use of the mechanical lubricator is also very advantageous on shunting engines and engines which do a lot of standing, because in that case there is no consumption of oil while the engine is standing still; whereas if the box is trimmed in the ordinary way the oil keeps passing through at the same rate whether the engine is running or whether it is standing.

I would like to ask some of our American friends for a little information with regard to grease for locomotives. A few years ago I got some boxes complete from America fitted for grease lubrication, and the grease blocks, but for some reason or other we were unable to make them run satisfactorily, and they ran hot continuously. I was wondering whether the use of grease lubrication for locomotives is really being found satisfactory in America and whether it is being extended. I refer to the type of grease lubrication where a pad of grease is held up to the lower side of the journal and a perforated plate is interposed between the grease and the journal.

With regard to carriages, I was very interested in the tests which Mr. Maunsell described, and I am rather in agreement with Mr. Reid that we should get quite sufficient dissipation of heat without the necessity of going to great expense in machining the tops of axleboxes on the inside.

Some years ago I carried out a number of tests of the temperature of axleboxes using pads as against waste. A thermometer was embedded just in the top part of the pad so that it could not touch the bearing, and readings were taken after a run of about 150 to 200 miles. It was found on arrival that all the boxes were more or less warm; that is, they were at a temperature of over 100° Fahr. They were all very uniform. The boxes filled with white waste, however, were about 20° Fahr. higher, on the average, than the boxes fitted with pads. That is confirmation of what Mr. Reid says, namely, that it is the action of the air — the boxes rushing through the air — that cools the boxes, and that with a pad you can get much better cooling than you can if the box is filled up tight all round the journal with white waste.

With regard to bearings themselves I want to emphasise what I have recently come across, namely, the importance of tinning. The white metal bearing which we use on the London & North Eastern Railway, is practically the same as that used on the London Midland & Scottish Railway. I am talking of carriages. It has a tin base, but I find that unless the white metal adheres thoroughly to the brass there is a danger of the metal spreading. The method of tinning adopted must be very carefully watched so as to ensure that there is proper cohesion between the white metal and the bearing. We find that by hanging the bearing up after it has been metalled and tapping it with a hammer you can tell by the ring whether the white metal is sound. If it is not properly adhering it will sound dull and you will not get a metallic ring. In that case, after a very short time the bearing begins to spread and you have trouble but providing the bearing is properly tinned you will have no trouble at all.

The number of hot boxes we have on our main line trains is very small. It is very rare indeed, provided they are properly tinned. By attention to that I believe that difficulty is got over.

Another point is that the bearing itself should be very narrow. We run with

a bearing of about 1 1/2 inches to 2 inches wide only, and the pressures per square inch are 700 to 800 lb.; in fact, such vehicles are running up to 500 miles a day on express trains, and have been running for years, and in the case of those vehicles I think I am right in saying we have never had a hot box. I find that directly the bearing tends to get wide there is a much greater tendency for the box to heat.

With regard to the conclusions which Sir Henry Fowler read out, I want to point out one or two things which I thought were not quite right, particularly with regard to coaching and wagon stock. In No. 4 he says : « It is desirable that the pressure on the bearings should be kept within moderate limits, in order to lessen wear and reduce the liability to run hot. » One way of keeping the pressure within moderate limits would be to increase the width of the bearing, but my experience has been that though you do increase the width of the bearing you will not decrease the friction.

Then in No. 5 he says : « White metals having a lead base are the most widely used, and there seems no reason why they should not be universal. » Looking through Mr. Tête's very interesting paper I find in Appendix No. 4 that the bulk of the bearings have a tin base. As far as English railways are concerned the carriages all have tin bases practically, and it is only some of the American railways where they have lead bases. I think, therefore, that this conclusion is not a correct one. A lead base may be all right for certain wagons, but I suggest that it should read as a tin base for carriages, and a lead base, possibly, for wagons.

Then, with regard to Item No. 9 there has been no discussion on that point. Sir Henry Fowler says : « It is fairly general practice to recover and refine waste oil recovered from axleboxes or from discarded packing or pads. » I think it would be a great mistake to use the old oil over and over again on carriages, such as I have described, having a high pressure on the bearings. Our practice has been to use the oil again, but we use it on wagons, or by mixing it sometimes with grease to make wagon grease. We should have to make sure, however, that the oil was in proper condition before using it on new main line express carriages.

Mr. Wallis. — In America the use of grease in all coupled boxes is almost universal. I do not believe that 2 % of the locomotives in America use oil.

Mr. Lacoin (in French). — I agree with what Mr. Gresley has said as regards paragraph 5. The information given as regards lead base alloys is all right if you do not take into account the service which may be obtained from the bearings. There is, in my opinion, another factor to take into consideration, that is, the amount of the bearing metal which you can recover. You cannot recover more than about 30 % of a lead base alloy, whereas you can recover 90 % of a tin base alloy.

I think that this is very important from an economical point of view.

The President (in French). — As the time is getting on, I propose that we adjourn the session, and I ask the reporters on the first question to have a few words with the secretariat in order to go through the final summary.

— The meeting terminated at 5.10 p. m.

Meeting held on 24 June 1925 (morning)

Mr. WEISS, PRESIDENT, IN THE CHAIR.

The President (in French). — I will now call on Sir Henry Fowler to continue the discussion on the special report on question IV-B.

Sir Henry Fowler. — I do not know whether you would wish to take the summary straight away? There is very little time left.

The President (in French). — There are some remarks by Mr. Gresley.

Sir Henry Fowler. — One of them dealt directly with the summary, which I propose, with your agreement, to alter somewhat. Will you take the summary straight through? I do not at all agree with Mr. Lacoin with regard to roller bearings, but I do not want to speak upon that to day. Shall I deal with the summary?

The President. — Yes.

Sir Henry Fowler, then read the summary on « Axleboxes-Locomotives ».

Axleboxes. — Locomotives.

1. — Cast steel is the most widely used material for engine axleboxes. The use of non-ferrous alloys by a few administrations may be referred to.

2. — Dust shields should be fitted whenever possible.

3. — It is advisable to keep down the bearing pressure as far as possible in order to reduce wear and avoid hot bearings. It would seem that a close study of this point would be useful, although in some cases it is governed by factors of design not pertinent to this question.

4. — The most suitable class of white metal depends upon the conditions under which it is used. Generally speaking a tin-base alloy is more suitable when an alternating or hammering action has to be sustained, but a lead base should be suitable for other cases.

Mr. Gresley criticised the last part of paragraph 4.

Sir Henry Fowler agreed to slightly alter the wording; the French text remaining unchanged.

5. — Mechanical lubrication, though still in an experimental stage on the majority of administrations which have adopted it, is giving encouraging results, and its application is extending.

6. — No administration reports the fitting of ball or roller bearings to axleboxes of coupled wheels.

7. — Mineral oil is almost universally used, a certain number of administrations adding a small proportion of animal or vegetable oil. In America grease lubrication is general for coupled axleboxes.

Sir Henry Fowler then read the first four paragraphs on « Axleboxes. — Coaching and wagon stock. »

Axleboxes. — Coaching and wagon stock.

1. — Cast steel appears to be the best material for modern high capacity stock, especially where subjected to rough usage.

2. — The open fronted or « one piece » body type of axlebox is the most widely used.

3. — Careful attention should be given to guard against loss of oil from, or rain water entering, the axlebox. Dust shields in some cases appear capable of improvement.

4. — It is desirable that the pressure on the bearings should be kept within moderate limits, in order to lessen wear and reduce the liability to run hot.

Mr. Gresley. — I called attention to this yesterday. I would like the last two lines eliminated, and words substituted so that it would read as follows : « It is desirable that the pressure on the bearings should be kept within moderate limits, and the use of narrow bearing surfaces is advocated. » My reason for that is that one might reduce the pressure per square inch by increasing the width of the bearings, but that would entirely defeat the object which we have, which is to lessen the number of hot boxes. I suggest that those words should be added.

Sir Henry Fowler. — I do not accept that. I should like to hear the views of the meeting on the subject. I think that that is not at all right.

Mr. G. Bianchi, Italian State Railways (in French). — I think it would be better to consider the work dissipated in friction. The work dissipated in friction is a function of the pressure multiplied by the speed. One may have a very high pressure, but a very low speed, and overheating will not occur. In Italy, our calculations are based on the energy dissipated in friction and not on the pressure, there being two factors which have to be taken into account.

The President (in French). — Shall we agree to the following text :

« It is desirable that the frictional resistance of the bearing shall be kept within reasonable limits?... »

Sir Henry Fowler. — I am not clear what that means, but if it is clear to the majority of the delegates, they will probably acquaint me later with the meaning.

The President (in French). — Did you understand what Mr. Bianchi said?

Sir Henry Fowler. — Yes.

The President (in French). — I think Mr. Bianchi is quite right in his remarks. It is not a matter of pressure; it is a question of the work of the energy dissipated in friction.

Sir Henry Fowler. — It is, but it seems to me that that is also dependent upon the pressure.

The President (in French). — Pressure and speed. Gentlemen, do you accept that wording?

Mr. Gresley. — What does it mean? Does it help us in designing a bearing?

Sir Henry Fowler. — Yes, it does.

Mr. Gresley. — The speed on railways is practically a regular and fixed speed, working up to a certain rate of speed and never going any faster.

Sir Henry Fowler. — That is so, but you get a very high pressure on the bearings of a wagon which runs only at 20 miles an hour. You would have a very big bearing on a coach which ran at high speeds; although I know Mr. Gresley does not agree with that.

Mr. Gresley. — There would be a very large number of hot boxes straight away. The wider the bearing, the greater is the tendency to heating. I do not know whether that is the experience of other delegates, but the experience which I have had has been that if you do have wide bearings, you have a tendency to heating: and I was anxious that, if the delegates agree, we should put something into this conclusion which would confirm that the use of narrow bearings is to be advocated because of the greater tendency to heating if you have wide bearings for carriages.

Mr. G. Bianchi (in French). — When the width of the bearing is greater, the pressure is reduced.

Sir Henry Fowler. — I would point out that there are very great variations in the matter which has been put before us, even in the section with which I have dealt, which is the British Empire. On some passenger stock on the Metropolitan District Railway (which I admit does not run at very high speeds) there is a pressure of 1 120 lb. per square inch, and 400 to 500 lb. per square inch appears to be an average figure for coaching stock. In the case of wagon stock the minimum is 280 lb. and the maximum is 706 lb. per square inch. I have not had an opportunity of looking at the other figures.

Mr. Duchatel, Eastern Railway, France (in French). — One might satisfy everybody by wording the paragraph as follows : « It is desirable to reduce the width of the bearing, at the same time keeping the pressure within reasonable limits so as to reduce the amount of wear and the risk of hot boxes. »

Mr. Bals, Roumanian State Railways (in French). — We should also mention the question of speed, so as to keep the friction within suitable limits for the speed at which the vehicle is normally intended to run.

Mr. G. Bianchi (in French). — In Italy, the wagons are divided into various categories in accordance with their speed and the loads which they have to carry. This classification is made by considering, amongst other factors, the frictional loss in the bearings.

Sir Henry Fowler. — I prefer Mr. Duchatel's reading.

Mr. Gresley. — I cannot see the object of Mr. Bianchi's suggestion of having four different types of stock running at four different speeds, because as regards cost, the bearing which would provide for the fastest train is a narrow one, and therefore it is not an expensive one, and therefore if it will run a train at 60 miles per hour without running hot, why have another bearing for a wagon which is going to run at 20 miles an hour, unless you are going to make a very much cheaper bearing? I submit that if you have one bearing it is much more convenient, because any of your stock then can run at any speed. Make it all up to the standard of the high speed, and do not divide it up unless you are going to get some saving in money by so doing. We consider that the narrow bearing is the best for the high speeds, and presumably it will be quite right for the low speeds.

Mr. G. Bianchi. — A bearing which is suitable for the fastest speeds is available also for the other speeds, but if you have a bearing which is only suitable for slow speeds, you cannot put rolling stock which is constructed with that bearing into the fast trains.

Mr. Gresley. — Not for other reasons; but as far as the bearings are concerned the bearings might be the same; might they not? What difference do you have between bearings for express trains and bearings for slow trains?

The President (in French). — I propose that we leave this question in abeyance and appoint a small committee to discuss this paragraph of the final summary and redraft it. Meanwhile, we will continue with the discussion of the other paragraphs.

Sir Henry Fowler. — I think that in reality what has been put forward meets the case of Mr. Bianchi, Mr. Duchatel's suggestion is that it is desirable that the

width of bearing of the brass on the journal should be kept narrow, and that at the same time the pressure should be kept within reasonable limits. I think that really meets the case of our Italian friends.

Mr. Gresley. — I accept Mr. Duchatel's suggestion.

Mr. Wallis. — I suggest the addition of the words, « due consideration being given to speed ».

The President (in French). — We will come back to No. 4 after finishing the others.

Sir Henry Fowler. — Paragraph 5 is one upon which Mr. Gresley spoke yesterday, and although I still think that the most widely used is a lead base, bearing in mind the very large amount of stock which our American friends have, yet in order to meet the case I have made this suggestion, with the agreement of Mr. Tête : « White metals with a tin base are used in many cases in Europe and the British Empire. In America a lead base is universally employed, and its extended use is worthy of consideration. A lead base is used for wagons in the majority of cases. »

Col. R. Collins, South African Railways. — I would like to draw attention to the fact that under the heading « Locomotives » we are recommending a tin base alloy for white metal. We are now recommending a lead base for carriages and wagons.

The President (in French). — No, we are speaking here about coaching and wagon stock; we do not speak about locomotives. We have already discussed locomotives.

Col. R. Collins. — I want to draw attention to the fact that we are recommending one alloy for locomotives, and a different one for carriages and wagons.

Sir Henry Fowler. — No.

Col. R. Collins. — Yes, that is so, I think. The point I want to make is that the second-hand white metal which is taken from the locomotives should be available for the carriage and wagon bearings, otherwise a railway which adopts two different types of white metal, or three different types, including metallic packing, which is probably universally used now, very soon gets into great difficulties, and it is found that eventually the material becomes a mixture of tin, lead, copper and antimony. I want to suggest to the meeting, if I may, that it is advisable for carriage and wagon stock bearings to be made of white metal with the second-hand metal which comes from the locomotives.

Sir Henry Fowler. — This is a matter which we have discussed in this country for a considerable time, and the matter has been up before the Association of Railway Locomotive Engineers, which includes all the railway locomotive superintendents in this country. We have standardised three metals : one is a tin base which is universally one having 85 % of tin; one, which is employed on the Great Western Railway, where thanks to the forethought of Brunel (which afterwards disappeared as far as the size of the stock generally went) they had big bearings, is a metal in which they have about 60 % of tin; and then for wagons and for other stock, we have standardised a lead base having 75 % of lead. On my own road we have for many years used the two : the 85 % tin and the 75 % lead, as being the base. We have not found that difficulty which Col. Collins speaks of, acutely. I am sorry to take so great a part in this discussion, but this is a subject to which

I have given considerable attention and therefore it is difficult for me to restrain myself. That is our experience.

Mr. Gresley. — I think Col. Collin's point would be met if you eliminated this. You say : « In America a lead base is universally employed, and its extended use is worthy of consideration. » That is what Col. Collins does not agree with, I think?

Col. R. Collins. — It is the use of second-hand metal which comes from the locomotives that I am concerned with.

Mr. Gresley. — The situation is that white metals with a tin base are used in most cases in Europe and in the British Empire, and that in America lead is used; and Sir Henry Fowler suggests that its extended use is worthy of consideration. I do not agree with that. I mean I do not think we should go that length, because I agree with you that a lead base is undesirable for carriages and wagons, for one of the reasons which you mentioned, namely that you can use your scrap metal again, whereas you cannot if it is a lead base; and it is much more satisfactory for preventing the heating of boxes, we think. I suggest that those words should come out, namely « Its extended use is worthy of consideration », and that we should simply state what is happening.

Sir Henry Fowler. — Yes, I agree; but I am hoping that Mr. Gresley will think that it is worthy of consideration. I do not know whether that would satisfy Col. Collins?

Col. R. Collins. — Yes.

Sir Henry Fowler. — Then I will suggest that we say : « White metals with a tin base are used in many cases in Europe and the British Empire. In America a lead base is universally employed. »

The President (in French). — I propose, Gentlemen, to continue the discussion on this point at another meeting.

Sir Henry Fowler :

6. — Oil lubrication is universal for up to date stock. Practice is divided between the use of pads and packing. Either method appears satisfactory if proper attention is given to design and maintenance.

7. — Roller and ball bearings have been experimented with by several administrations. Information is somewhat limited and not entirely in agreement.

Experience is not of sufficiently long duration to determine depreciation and upkeep. The first cost of fitting is high. It would appear that these bearings are best adapted for use on suburban vehicles, as they give a lower frictional resistance in starting.

Mr. Lacoin (in French). — I would like to clear up a misunderstanding which may have arisen during the course of the discussion yesterday. We all agree that roller or ball bearings reduce the resistance when starting. However, this reduction soon disappears, and although starting is made easier, no appreciable economy is produced in the fuel consumed.

I propose the following wording : « Roller and ball bearings have been experimented with by several administrations. These bearings certainly reduce the frictional resistance, but experience is of too short a duration to determine maintenance costs of these boxes and whether the considerable first cost is justified by the reduction in the power required to haul the train. »

Sir Henry Fowler. — That is entirely against the experiments which I personally have carried out here. We have found that the bearing is easier to start, but after it has started we have not found that there is any advantage.

The President (in French). — That is what Mr. Lacoin said.

Sir Henry Fowler. — I understood Mr. Lacoin to say yesterday that when the speed was moderate he found that there was a reduction. I think he quoted a speed of 25 miles per hour.

The President (in French). — He does not say so now.

Mr. Lacoin (in French). — There are two things : there is firstly reduction at the immediate moment of starting; we quite agree in that; but if we calculate it on the mean efforts of traction, we find that the economy is much greater at speeds of 25 miles per hour than in the case of trains which have frequent stops.

Sir Henry Fowler. — Our experience, which has been published, and upon which Mr. Reid spoke yesterday, was that we got no economy in running for 100 miles at a speed of over 50 miles per hour.

Mr. Lacoin (in French). — We have had certain economies.

Sir Henry Fowler. — We have not had any; but is Mr. Lacoin satisfied with the summary?

Mr. Lacoin (in French). — No, I have suggested another form of wording.

Sir Henry Fowler. — I am not clear upon it. Perhaps you would be good enough to read it again.

Mr. Lacoin (in French). — « Roller bearings have been experimented with on some administrations. They reduce to a large extent the tractive effort — the starting effort or the traction effort — but the test is too recent to ascertain if the maintenance of those bearings is economical, and if the high first expense is sufficiently justified by the reduction of the effort of traction. »

Sir Henry Fowler. — I rather object to the expression about the reduction of the effort of traction, because it is only at the very start that we have found that there is any reduction.

Mr. Lacoin (in French). — We have found also a reduction at 25 miles per hour, and a very noticeable reduction.

Sir Henry Fowler. — With the dynamometer car we have carried out experiments for several days, and we have not found it. It is only in those last few words that I do not agree with Mr. Lacoin. If he would leave it that we do not yet know whether it will justify the expense, I shall be content.

Mr. Lacoin. — I say that it is doubtful if it is justified by the reduction of the effort of traction. I thought that would give you satisfaction.

Sir Henry Fowler. — No, because we say in point of fact that our figures show that a well lubricated plain bearing when you are running at some speed, is not only every bit as good as, but is slightly better than, a roller bearing. Therefore if we could come to an agreement on this question as to whether the expense is justified by the economy which you get, that would really be the point; but Mr. Lacoin gets something different from us.

The President (in French). — As it is getting late, I propose to adjourn the discussion to another meeting.

Our section will meet to morrow with 3rd section.

— The meeting terminated at 12.50 p. m.

Meeting held on the 26 June 1925 (afternoon).

Mr. WEISS, PRESIDENT, IN THE CHAIR.

— The meeting opened at 2.15 p. m.

The President (in French). — I propose that we proceed with the discussion of the final summary of question IV-B, which is not yet completed.

Sir Henry Fowler has kindly drawn up the amended final summary, and I will ask him to speak.

Sir Henry Fowler. — These are the points that I have discussed with Mr. Tête, and we are in agreement, and hope the meeting will accept them.

4. — It is desirable to consider in the design the width of and pressure on the bearing and the speed at which the vehicle runs.

— Adopted.

5. — White metals with a tin base are largely used in Europe and the British Empire. In America a lead base is universally employed.

Mr. G. G. Elliott, South African Railways (1). — May I make a suggestion? No figures have been put in as regards the actual wear of these different metals. Before I left South Africa some time ago I made a special hobby of this white metal question and tested all kinds of mixtures. I have definite figures to show what the amount of wear of the metals in coaches and wagons is. I think if all the railway administrations which are represented here would experiment and at the next Congress put up their figures they would be able to decide on a much vexed question. No doubt many of the railway companies have the figures now.

The President (in French). — I hope that the Permanent Commission will make a note of this proposal.

Sir Henry Fowler. — I do not think we had any reply from South Africa to our enquiries.

Mr. G. G. Elliott. — That is so. As a matter of fact we have been having quite a big controversy out there on the mines as well as the railways as to the merits of the various mixtures.

Sir Henry Fowler. — We had no figures given to us.

Mr. G. G. Elliott. — No. These are my own special figures which I got out while I was assistant to the Chief out there.

Sir Henry Fowler :

7. — Several administrations have experimented with roller and ball bearings. It has been found that there is considerable reduction in starting effort, but the results obtained for the tractive effort required at speed are not in agreement. The first cost of fitting these bearings is high. The trials have not been carried out for a sufficient length of time to allow of a definite statement being made as to the cost of maintenance.

8. — Majority of administrations use mineral oil without any addition of animal or vegetable oil.

9. — It is fairly general practice to recover and refine waste oil recovered from axleboxes or from discarded packing or pads.

10. — It is very desirable, especially as regards wagon stock, that standardis-

(1) See also Mr. G. G. Elliott's letter published as appendix.

ed types of axleboxes be adopted so as to reduce the necessary stock of spares, and in order that the examining and repair staff may become accustomed to the design and carry out their work more expeditiously.

The President (in French). — As no criticisms have been offered, I take it that the final summary proposed by Sir Henry Fowler is agreed to.

— I will now close the discussion.

DISCUSSION AT THE GENERAL MEETING

Meeting held on 27 June 1925 (morning).

PRESIDENT : THE RIGHT HON. VISCOUNT CHURCHILL.
GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. GHILAIN.

Sir Henry Fowler, *General Secretary*, read the final summary adopted by the 2nd section.

This final summary gave rise to no comments.

The President. — The final summary is therefore as follows :

Final summary.

« *Axleboxes : Locomotives.*

« 1. — Cast steel is the most widely « used material for engine axleboxes. « The use of non-ferrous alloys by a few « administrations may be referred to.

« 2. — Dust shields should be fitted « whenever possible.

« 3. — It is advisable to keep down the « bearing pressure as far as possible in « order to reduce wear and avoid hot « bearings. It would seem that a close « study of this point would be useful, « although in some cases it is governed « by factors of design not pertinent to « this question.

« 4. — The most suitable class of « white metal depends upon the condi- « tions under which it is used. Generally « speaking a tin-base alloy is more suit- « able when an alternating or hammering « action has to be sustained, but a lead « base can be used for other cases.

« 5. — Mechanical lubrication, though « still in an experimental stage on the « majority of administrations which have « adopted it, is giving encouraging re- « sults, and its application is extending.

« 6. — No administration reports the « fitting of ball or roller bearings to axle- « boxes of coupled wheels.

« 7. — Mineral oil is almost universal- « ly used, a certain number of adminis- « trations adding a small proportion of « animal or vegetable oil. In America « grease lubrication is general for « coupled axleboxes.

« *Axleboxes : Coaching and wagon stock.*

« 1. — Cast steel appears to be the best « material for modern high-capacity

« stock, especially where subjected to « rough usage.

« 2. — The open-fronted or « one- « piece » body type of axlebox is the « most widely used.

« 3. — Careful attention should be « given to guard against loss of oil from, « or rain water entering the axlebox. « Dust shields in some cases appear ca- « pable of improvement.

« 4. — With bearings for carriages « and wagons, it is desirable to consider « in the design, the width of and pressure « on the bearing, and the speed at which « the vehicle runs.

« 5. — White metals with a tin base « are largely used in Europe and the « British Empire. In America a lead « base is universally employed.

« 6. — Oil lubrication is universal for « up-to-date stock. Practice is divided « between the use of pads and packing. « Either method appears satisfactory if « proper attention is given to design and « maintenance.

« 7. — Several administrations have « experimented with roller and ball « bearings. It has been found that there « is considerable reduction in starting « effort, but the results obtained for the « tractive effort required at speed are not « in agreement. The first cost of fitting « up these bearings is high. The trials « have not been carried out for a suffi- « cient length of time to allow of a defi- « nite statement being made as to the cost « of maintenance.

« 8. — Majority of administrations use « mineral oil without any addition of « animal or vegetable oil.

« 9. — It is fairly general practice to « recover and refine waste oil recovered « from axleboxes or from discarded « packing or pads.

« 10. — It is very desirable, especially « as regards wagon stock, that standardis- « ed types of axleboxes be adopted so as « to reduce the necessary stock of spares, « and in order that the examining and « repair staff may become accustomed to « the design and carry out their work « more expeditiously. »

— This final summary was ratified by the General Meeting.

APPENDIX

Letter from Mr. G. G. ELLIOTT, delegate of the South African Railways & Harbours at the session of the London Congress

Trafalgar Square, London, W. C. 2.
2nd February, 1926.

To the General Secretary of the Permanent Commission
of the International Railway Congress Association,
Rue du Progrès, 74, Brussels.

Dear Sir,

Your No. 3826 of the 30th January. I return the minutes corrected.

There was so little time to discuss the matter that I was unable to give the Congress some very useful details, so if you care to publish the following it may be of some use to Railway Companies who could run some trials before the next Congress, and they would be able to prove for themselves whether their experiments agree with mine.

1. — The amount of wear on a bearing depends entirely on the degree of hardness of the metal.

2. — The only reason why white metals are wanted at all is because being soft and plastic they do what the best fitter cannot do, they mould themselves to the journal quickly, and so even up the pressure all over. A hard metal like brass or bronze bears on the high points, and all the pressure concentrates on those high points, so much so that the oil will not lubricate them.

3. — The coefficient of friction of all white metals is higher than the harder brasses and bronzes, and white metal has not such good antifrictional properties except that due to its softness.

4. — A high tin base metal hardened up with copper or antimony is an excellent metal, and gives the desired degree of hardness for all bearings.

5. — A lead base metal hardened with antimony or tin or both cannot be made as hard as a tin base metal, and therefore wears faster.

6. — A lead base metal can however be used on coach and wagon bearings without fear of hot boxes, but the life is approximately only a quarter of that of the tin base. No lead should be used for locomotive bearings. The service is more severe and trouble arises at once. A tin base metal is much better and even then it has to be well housed so as to prevent it squeezing out.

7. — The cost of these two types of metals is a matter to be considered. For every 200 000 bearings some 270 t. of tin mixture would be required. If a lead base is used from 33 to 40 % more would be used as lead is about that much heavier.

The London price of tin is now about £280 per ton; lead is only £35. 270 t. of tin base (83 tin to 6 copper, 11 antimony) would cost £63 000 for the tin alone, and 360 t. of lead base (80 lead, 20 antimony or 80 lead, 15 antimony,

5 tin) would cost only £10 080 for the lead alone and about £5 040 for the tin content. These quantities would always be floating about on the rolling stock and in addition the numerous workshops and running repair sheds would have to keep stocks which would enhance these figures considerably, and the only feature that would reduce the tin cost would be cost of repairs as the life would be much greater but he would be a bold man who could give a definite figure, but the relative wears are from one and a half to three ounces per annum for a tin base and six to twelve ounces for a lead base metal. The crown wear is very slight but the end wear is quick and decides the life, and the higher the speed through centrifugal action the greater the side pressure and wear.

8. — The best results on a vehicle will give the best results on a locomotive, and as testing a coach is quick and simple, tests on a locomotive are unnecessary. The coach gets big mileage much sooner than a loco or truck, so trials should be run on a coach.

9. — The bearings should be washed in paraffin to get rid of the oil and be weighed on a very accurate bullion scale to the nearest gramme.

10. — A cheap mineral axle oil will be good enough for any of these metals, but the better the oil the better the metal will behave.

11. — If lead could be hardened up to a degree equal to the tin base by a cheap process then it would answer equally well.

Yours faithfully,

G. G. Elliott,

Advisory Engineer.

[621 .335]

QUESTION V.

HIGH SPEED ELECTRIC LOCOMOTIVES.

Preliminary documents.

1st report (America), by Mr. J. T. Wallis. (See English edition of the *Bulletin*, January 1925, p. 179, or separate issue [with red cover] No. 15.)

2nd report (other countries), by Mr. M. Weiss. (See English edition of the *Bulletin*, April 1925, p. 1019, or separate issue [with red cover] No. 33.)

Special reporter : Mr. M. Weiss. (See English edition of the *Bulletin*, June 1925, p. 2111.)

DISCUSSION BY THE SECTION

Meeting held on 26 June 1925 (morning).

Mr. WEISS, president, in the chair.

— The meeting opened at 9.30 a. m.

Mr. President (in French). — We have still to examine the question of axleboxes (question IV), in all its detail, but I think it is preferable that we should take, to day, question V (electric locomotives), in order that the delegates present who are not concerned with the question of axleboxes may be spared the necessity of attending again.

As it is my desire to take part in the discussion, I shall ask Mr. Lacoin, vice-president, to be kind enough to take the chair of this section.

Mr. LACOIN, Vice-President, in the chair.

The President (in French). — I call upon Mr. Weiss.

Mr. Weiss, *Special Reporter* (in French). — The summary of the questions dealt with in each of the reports, has enabled the following findings to be obtained :

1. — There are only relatively few high-speed electric locomotives — running at speeds above 46 miles per hour — in service or at present being constructed. These locomotives run on or are intended for the following railway systems :

America :

Chicago, Milwaukee & St. Paul (Ch., M. & St. P.);

New York, New Haven & Hartford (N Y., N. H. & H.);

New York Central (N. Y. C.);

Chilean (F. F. C.);

Paulista (C. P.);
Pennsylvania Railroad (P. R.).

Germany :

German State Railways (D. R. B.).

Austria :

Austrian Federal Railways (B. B. Oe.).

England :

Metropolitan Railway.

France :

French Midi Railway (Midi);
Paris, Lyons & Mediterranean Railway (P. L. M.);
Paris Orleans Railway (P. O.);

The two last are in process of electrification.

Italy :

Italian State Railways (F. S.).

Sweden :

Swedish State Railways (S. I.).

Switzerland :

Swiss Federal Railways (C. F. F.).

2. — We have only received information on high-speed locomotives without carrying axles operating on the Metropolitan Railway, the P. O. and the N. Y. C.; the two latter administrations have also locomotives with carrying axles and bogies.

3. — The transmission of the tractive effort from the motors to the driving wheels is effected by very varying methods. The following are to be noted :

a) Direct drive by connecting rods on the P. L. M. on the trial 2B1 + 1B2 locomotive of the Auvert system, on the P. O. in the 2B + B2 locomotive of the Ganz system, on the F. S. on all their electric locomotives, on the S. I. on the 2B2 type locomotives, on the D. R. B. on several types of locomotives, and also on the P. R. on locomotives of the 2B + B2 type;

b) Drive through gearing and coupling rods; on the S. I. (types 2B + B2 and 1C1); on the C. F. F. (type 2C1); on the B. B. Oe. (type 1C1); and on the P. R. (type 1D1).

Direct drive is used in the following forms :

c) « Gearless » type on the P. O. (trial locomotive of the General Electric Company type 2C + C2); on the Ch. M. & St. P. (1B + D + D + B1), and on the N. Y. C. (type 2D2 and B-B + B-B);

d) Tramway type of drive : on the Metropolitan Railway (type B-B); on the P. O. (type B-B); and on the P. L. M. (type 1C + C1);

e) By the Westinghouse system : with hollow shafts and drive through springs : on the P. L. M. (type 2B + B2 on one half of the locomotive); on the C. F. F. (type 1C1); on the Ch. M. & St. P. (type 2C1 + 1C2); on the N. Y., N. H. & H. (type 1B + B1 and 1C1 + 1C1); on the C. P. (type 2B + B2 and 1B + B1);

f) Various systems : Brown, Boveri & Co. of Baden (Switzerland) (Buchli system) on the P. O. (type 2-D-2); on the C. F. F. (type 2C1 and type 1B1 + 1B1 on one half of the locomotive);

M. F. O. system : on the P. L. M. (type 2B + B2);

P. L. M. system : on the P. L. M. (type 2B + B2 on one half of the locomotive);

Tschanz system : on the C. F. F. (type 1B1 + 1B1 on one half of the locomotive);

Hollow shaft and connecting-rod system : on the P. L. M. (type 2B + B2 on one half of the locomotive).

g) Vertical motor system : on the Midi (type 2C2), and on the B. B. Oe. (type 1D1).

4. — The locomotives with connecting-rod drives have the advantage possessed also by steam locomotives, of having the centre of gravity higher than in the other types of locomotives, which is of importance for securing good running.

This arrangement, if well made and well maintained, provided that it is also fitted with spring driving gear, appears to give good results.

The rotating masses on electric locomotives can be accurately balanced so that there is no production, as in steam locomotives, of additional load due to hammer blow, hence it is possible to increase the axle loads (P. R. : type 1D1 locomotive 35 t.; C. F. F. type 2C1 locomotive, 20 t.).

5. — The methods of drive given under 3*f*) and 3*g*) have the same advantages in respect to height of centre of gravity and axle load as are obained with connecting-rod drives.

6.— With the Westinghouse drive, spring breakages frequently occur when axle load is high (Ch., M. & St. P., 28.6 t.), and when concentricity of the driving axle and of the hollow axle cannot be accurately maintained in service, a fact that is particularly to be feared on locomotives having more than three driving axles on one frame.

7. — In locomotives of which the height of the centre of gravity is relatively low, and therefore causes greater stresses in the superstructure (due to lateral shock), it is advisable to reduce the axle load as much as possible (P. O. 12.4 t.; N. Y. C. 15 to 17 t.).

8. — In order to obtain good stability in running for high speed locomotives, a long wheel-base should be provided.

9. — Leading wheels with lateral play (radial axleboxes) and leading bogies are generally fitted with restoring gear (springs or inclined surfaces). The restoring force varies greatly, from 0 kgr. (type 1C1, B. B. Oe.) to 6 700 kgr. (14 800 lb.) (type 1C1 of the C. F. F.) according to the various types of locomotives.

10. — The methods adopted for collecting current are generally of the two following types;

a) Overhead collectors of the pantograph or bow forms, which are in general use on lines using single-phase current, and are also often used on lines worked by continuous current.

In the case of all the administrations, the collector is raised by compressed air, with the exception of the Midi Railway, on which it is lowered by this means. The contact pressure of the collectors on the wire varies from 10 to 15 kgr. (22 to 33 lb.) for continuous current, and from 3 to 5 kgr. (6.6 to 11 lb.) for alternating current.

b) Collector shoes are only used on lines worked by continuous current.

11. — The main switch is either constructed with a magnetic blow-out, with or without high speed break (the latter process in coming more and more into use) for continuous current, or with a multiple-break oil break for alternating current.

The main switch is controlled differently on different administrations, either by hand, by compressed air or by electro-pneumatic control, or it is electromagnetic, or electric.

12. — The control gear appears to be settling down into the two following main forms :

a) For continuous current and to some extent for single-phase current in the form of a controller with contactors;

b) For alternating current, either in the form of controllers with contactors as above or in the form of cylindrical contacts or analogous appliances to those used on the B. B. C. locomotives, which consist of contacts arranged near together, with special contacts for breaking the spark.

The control of these appliances has the same variations as that of the main switch although it would appear that the electro-pneumatic control is in most general use up to the present.

13. — The transformers required on the single-phase locomotives, and to some extent also on the three-phase locomotives, are of the oil immersed type, or of the cooled air type.

Without wishing to enter into a discussion on the inherent advantages of one or other of these types of transformers, it may be said that the oil immersed type appears to be more favoured than the other.

The cooling of the transformer is generally affected by means of fans.

14. — The external form and the dimensions of the traction motors vary with each type of locomotive. Between the lower powered locomotives of 185 to 275 H. P., of the Metropolitan Railway and the Midi, to the highest powers of 3.000 H. P. of the D. R. B. all intermediate powers may be found. The mean value is from 550 to 600 H. P.

The cooling of the motors is, with few exceptions, effected by special fans.

Where continuous current is used, the question of insulation generally presents some difficulty; with alternating current on the other hand, the weak point is in the commutator. Experience shows, however, that the cost of maintenance under some conditions can be considerably reduced, and the mileage run after turning up till this is again required may be high (150 000 km. — 94 000 miles — on the S. I.).

15. — The auxiliary electric equipment of the locomotives does not vary appreciably for different types of locomotive.

The question of train heating has not yet been definitely settled, but appears likely to be generally effected, in Europe at any rate, by means of electric resistances on the trains.

16. — We should here remark that direct comparison between the power of these locomotives is rather difficult owing to the fact that at present there are no existing international standards that define the maximum permissible heating of the motors, and the methods by which the tests shall be carried out.

The weight in kilogrammes per horse-power at the tread of the wheel, as well as the power that can be developed for one hour, given in the comparative table for unit weight per H. P. can for this reason only be taken as approximate.

The interesting points to which we wish to draw special attention, and which we recommend particularly for discussion, are the following;

1) Is either the tram type or the « gearless » type to be recommended for the drive of high-speed locomotives, and for what maximum speed?

2) Under what conditions can good results be obtained with the Westinghouse drive, and what is the normal life of the springs?

3) Is it advisable to arrange for elastic (spring) transmission in the case of locomotives having connecting-rod drives, and should the gear be fitted with a shock absorber or not? Is it necessary to make special arrangements for adjusting the exact length of the connecting-rod in service?

4) In geared locomotives, what system has been found to work best, and what is the method of lubrication adopted?

5) As the result of present experience, is it better to adopt the connecting-rod drive or direct drive for high speed locomotives? Can these locomotives be fitted with radial axles (Bissel or Adams) and in this case, what conditions must be observed (weight per axle, restoring force etc.)?

6) Has it been found that the presence of the oil necessary for the circuit breakers used with alternating current or with the transformers gives rise to any danger in working?

In that event, have any steps been taken to prevent risk?

7) What is the type of remote control that has given the best results up to date (electric, electro-pneumatic, mechanical, etc.)?

8) To what figure has the maintenance of a continuous current motor and an alternating current motor been reduced? What mileage has been found possible without examination being required more than once a day?

9) What is the present mean distance run by electric high speed locomotives as compared with steam locomotives of the same class? Are any steps being taken for operating electric locomotives by a single man, and if so, under what conditions?

The President (in French). — We will commence the discussion on article 1.

Has Mr. Wallis, the second reporter, anything to add to the report of Mr. Weiss?

Mr. Wallis, *Reporter.* — Mr. President, I think that if the points that Mr. Weiss has laid down are all answered properly, they will answer, all the questions we want to ask in the United States. I am fully in accord with what Mr. Weiss has outlined.

Mr. Bachellery, Midi Railway, France (in French). — I wish in the first place to rectify an omission due to a misunderstanding, which has found its way into Mr. Weiss's report. If the limit of speed of locomotives that are classed as high-speed locomotives, is fixed at 46 miles per hour as a minimum, there should be added to the figures given by the Midi Railway, 25 locomotives which can run at 56 miles per hour. On the Midi Railway we think that the problem of high-speed electric locomotives only commences to present difficulties above a speed of 56 miles per hour. We have not included in the figures that we supplied, the 25 locomotives mentioned. These locomotives are of the double-bogie « tram » type with motors suspended by the nose.

The only trouble that we have found with that type of motor arises in the upkeep of the brushes. This is solely a question of commutation, which is affected by vibration; sparking occurred, which forced us to make alternations in the brush-holders. So far as the mechanical details are concerned, experience has shown that up to the speed of 56 miles per hour, it is possible for locomotives of the « tram » type to give a good performance on the track.

We have coupled the bogies together; it is necessary that the bogie coupling should be very close and tightened as

tight as possible. At the commencement we had a simple draw-bar, and as long as the locomotives were new, the joints remained tight and the arrangement worked well, but as soon as there was play, they worked badly, and some swaying movement was noted. It became necessary to tighten the coupling between the bogies. We were compelled to complete the coupling by inserting lateral buffers without springs between the two locomotives so as to allow of a relative vertical movement, but to oppose, when in contact, all transverse movement, in such manner that the bogies, when displaced, must bring the drawbar springs into action. Locomotives so arranged run perfectly well on the track up to speeds of 56 miles per hour.

For higher speeds we have given up the « tram » type and have adopted rigid frame locomotives with a leading bogie, following the same principle as that adopted for steam locomotives.

The President (in French). — We can limit the discussion for the present to locomotives of the « tram » type.

Mr. Japiot, Paris-Lyons-Mediterranean Railway (in French). — It will be well to distinguish, in the discussion, two types of locomotives having motors suspended by the nose, those that have two independent bogies and those that have two trucks (or radial axles) jointed together. It would be interesting to know up to what speed each of these types of locomotive can be run.

The President (in French). — I propose, Gentlemen, that we should first discuss the question of the suspended motors.

Cannot some of the delegates give us particulars relating to difficulties that they have encountered, particularly with the brushes?

Mr. Leboucher, Midi Railway, France (in French). — We have found that when the motors have not more than two brushes in line, and these brushes are comparatively heavy, the inertia of the brushes prevents their return to contact from being satisfactory. When the locomotive passes over points, the brushes are thrown up, and, owing to their great inertia, the return to contact is not effected sufficiently quickly, and produces arcing of the commutator.

We have endeavoured to overcome this difficulty by dividing the brushes into two, so as to diminish their inertia. The advantage obtained has been definite, and it appears that if the weight of the brushes could be still further diminished, very satisfactory results could be obtained.

We have made experiments increasing the speed up to 62.1 miles per hour, and we have succeeded in overcoming the trouble which I have mentioned as due to the use of too wide brushes.

Mr. Bianchi, Italian State Railways (in French). — We have also tried a coupling for locomotives of the C + C type consisting of two bogies connected by a spherical coupling rigid in all directions. These locomotives have been run up to 62.1 miles per hour, without giving the least trouble at this speed. The motors run at 900 revolutions per minute, and at a voltage of 600 volts. In my opinion, the question of commutator depends mainly on the working voltage.

Mr. Japiot (in French). — Were the motors in question arranged with elastic or rigid gearing?

Mr. Bianchi (in French). — The mo-

tors were suspended by the nose with springs and rigid mounting.

Mr. Wallis. — We have had very little experience of that nature. Our experience has been largely with cars, and there we have had trouble with brushes as mentioned. The brush trouble has not been overcome with the single phase motors or with the commutating pole motors.

The President (in French). — It would be of interest to know whether high speeds can be obtained with separate bogies and, if the bogies are connected, what types of connection are to be preferred?

Mr. Weiss (in French). — The Swiss Federal Railways have only one high-speed locomotive with driving bogies (1B1-1B1). They have, however, a fairly large number of passenger-train locomotives (type 1B-B1 and 1B1-B1) that run op to 46.8 miles per hour.

We have had difficulties with the locomotives running on the Gothard line on curves of small radius (less than 15 chains) as we have found considerable wear of the flanges of the tyres. In order to reduce this difficulty, we have adopted a transverse coupling between the bogies in such manner that the leading bogie can guide the trailing bogie, so that this will not exert so high a pressure on the outer rail. We have thus considerably reduced the wear of the flanges.

Mr. Bachellery (in French). — The remarks made by Mr. Weiss apply to lines having curves of short radius and on which the speeds are not very great. Experiments made by the Midi Railway on bogie locomotives relate to speeds sensibly greater than 46.8 miles per hour, and have enabled us to confirm the advantage of a coupling between the bogies. The need for this has been recognised not only for curves but also for the straight where the high-speed locomotives may acquire a swaying movement that may become a serious trouble. We have, therefore, on this railway system, coupled them as tightly as possible, and used lateral buffers.

Mr. Japiot (in French). — What method is adopted for restoring the bogies? It is probable that the method used is of importance in entering curves and also influences the swaying motion produced on the straight at high speed.

M. Weiss (in French). — The locomotives to which I have alluded are fitted with a coupling so rigid that there is no question of restoring to position.

Mr. Japiot (in French). — A restoring force may act between the bogies and the body.

Mr. Weiss (in French). — There is no restoring force applied on locomotives of these types.

Mr. Leboucher (in French). — The locomotives of the French Midi Railway had in the first instance a trifling restoring force. The two bogies were connected by an American coupling consisting of a coupling bar and central buffer with an intermediate piece of double concave form gripped between two convex buffers. To avoid swaying, double buffers were adopted consisting of two dumb buffers, because it was necessary to maintain an exact and constant distance between the axes of the two bogies. The buffers are kept in contact by a central spring which forms the coupling between the bogies. In order that the body should not be subjected to stress, only one of the bogies is attached to it; the other can

slide longitudinally. When the locomotive enters a curve, the buffers on the side of the small radius remain in contact, those on the outside move apart and compress the coupling spring.

There is consequently a restoring force applied between the two bogies that prevents swaying.

Mr. Parodi, Paris-Orleans Railway (in French). — I should like to recall, from the historical point of view, that trials were made more than 20 years ago on the line from Marienfeld to Zossen (Germany) at a speed of 125 miles per hour, with six-wheel bogies, the axles not being coupled, and with gearless motors. I wish to recall this in order to show that there is no absolute rule governing the conditions under consideration.

Any system can be used, provided that suitable and special arrangements are made to suit the circumstances of the case.

Mr. Bachellery (in French). — It is evidently possible to select arrangements, that allow locomotives with two separate bogies to run at high speed, but, in the case mentioned by Mr. Parodi, a railway had been constructed which in no respects resembled existing railways. In particular, a check rail had been laid from end to end of the line. The bogies were of the six-wheel type with a wheelbase of from 9 ft. 10 in. to 11 ft. 6 in.

Mr. Parodi (in French). — These very special arrangements were due to other reasons, particularly the inertia of the body, which was very long.

Mr. Japiot (in French). — I think that in America particularly on the New York Central, the restoring force acts between the bogie and the body.

Mr. Wallis. — I do not think I have sufficient detail to communicate on this subject. I do not know how far the New York Central Railway has been satisfied with the arrangement; that Company did not send a reply to this question.

The President (in French). — No other observation having been made, we will now pass to the discussion of Article 2.

Mr. Weiss has mentioned that on bad tracks and at high speeds the springs used in the « Westinghouse » control break frequently. Can anyone give us information with regard to this?

Mr. Wallis. — In my opinion, Mr. Weiss has worded his findings with great care and has shown the result that we obtain in America. His findings state our conditions very clearly and completely (1). I agree with this wording entirely.

The President (in French). — We will now proceed to Article 3.

Mr. Parodi (in French). — The question before us should be looked at from two points of view, those of theory and practice. From the theoretical point of view, the Paris-Orleans Railway thought that the only method of studying the question was by direct trial. It therefore ordered two locomotives with coupling rods, absolutely identical in mechanical features, but in the one case with hyperstatic coupling rods without elastic connection, but connections working in parallel, and the other with isostatic transmission with springs inserted between the armature and the shaft with all the connections in series.

These locomotives will be delivered dur-

(1) Paragraph 6, p. 2112, of the *Bulletin of the International Railway Congress Association* for June 1925.

ing the present year or at the beginning of next year, and when they have been on trial, we shall be able to say definitely which of the two arrangements is the better. All that can be stated at present is that five locomotives using continuous current at 500 volts, which were delivered to us immediately after the war, fitted with isostatic transmission by coupling rods and restoring springs between the axle and the armature, have not caused us difficulty.

Mr. Bianchi (in French). — All the electric locomotives that we have in Italy (535 locomotives in service) have coupling rods and rigid transmission. The disadvantage that we have found arises from the fact that if the motor is short-circuited, damage may occur even in the mechanical parts.

It is not possible to put springs between the armature and the axle because, in the case of a three-phase locomotive, the primary and secondary windings of the motors, being generally in parallel when starting, the two motors might get out of phase.

No means for adjustment is provided for the length of the coupling rods, the adjustment being made at the works, and passenger-locomotives can run 62 000 to 75 000 miles without further adjustment.

The President (in French). — With what play?

Mr. Bianchi (in French). — A slight play of one-fifth of a millimetre (0.008 inch), which gives rise to no difficulty in running.

It is necessary that when the adjustment is made in the shops, a perfect fit should be obtained.

The President (in French). — Is there no adjustment made at each overhaul?

Mr. Bianchi (in French). — No, moreover, the system is not fitted with any means of adjustment. In particular, there is no provision, such as is made in steam locomotives, of wedges for permiting wear to be taken up.

Mr. Wallis. — In the United States it is the general feeling that all locomotives should be fitted with springs between the connecting rods and the motor shafts. There are, however, some locomotives running without them, and there is a tendency to do away with them on locomotives running at low speeds. It is very difficult to say at the present time how far this tendency will extend to high-speed locomotives. To day, the American railways running high-speed locomotives generally fit them with springs or some form of damping arrangement between the motor and the connecting rods.

The President (in French). — Have you had any difficulty in the maintenance of the connecting rods?

Mr. Wallis. — Very little up to the present time. One railway had trouble, but this arose from defective design which should have been put right in the first instance.

The President (in French). — Have you anything further to say, Mr. Wallis?

Mr. Wallis. — I should like to call attention to a matter of detail. The Pennsylvania Railroad have 33 locomotives running on the service from New York. They are not fitted with these springs and have been running for a long while. They are, however, fitted with an arrangement that allows the crank to slip on the motor shaft. Up to the present, we have found that this slipping occurs very seldom; the arrangement very rarely comes into play. It acts through the in-

tervention of pressure exerted on a disc and it is believed that by this means the inertia difficulties are overcome. In our experience, however, it very rarely comes into action.

The President (in French). — We will now commence the discussion of Article 4.

Mr. Weiss (in French). — The Swiss Federal Railways use various arrangements of gearing. Up to the present, we have found no difficulty with any of these systems. Trials that are now being undertaken have not been of sufficient duration for us to be able to make a definite statement. It is evident that the gearing must be very well made and fitted. The lubrication system uses oil only and has given satisfaction generally. The only difficulty that has occurred has been in the tightness of the gear cases.

Mr. Bachellery (in French). — The following particulars will be of interest, relating to the geared locomotives in use on the Midi Railway System.

With the « tram » type of locomotive, we had at first some difficulties due to broken axles. The direct keying of the toothed wheel to the axle caused cracks in the body of the axle which increased rapidly and caused fracture. To avoid this risk, we gave up securing the gear wheel to the axle, but fixed it to the body of the wheel in such manner that the drive was transmitted to the wheel itself.

When the force transmitted is very large, we fit a gear wheel at each end of the axle, so as to distribute the effort. For lubrication, we use thick grease put into the gear-cases. By this means, we avoid the trouble mentioned by Mr. Weiss arising from want of tightness of the gear-cases.

Mr. Wallis. — On the latest locomotives of the Pennsylvania Railroad, we have adopted the same method for securing the gear wheel. The shaft passes through the boss of this wheel so that the arrangement is similar to that described by Mr. Bachellery for large locomotives.

Mr. Leboucher (in French). — It appears to me that the system of gearing used on the 2-C-2 locomotives will be of interest to this section. As Mr. Weiss has stated in his report, the motors of these locomotives are vertical, and force is transmitted by means of a bevel pinion to a bevel gear carried on a hollow axle. The lubrication is forced. I believe this is the first case in which this system of lubrication has been used for this purpose, though it is in general use in marine practice particularly on torpedo boats. The oil is sucked by a pump arranged at the bottom of the gear-case and is pumped through filters into a special reservoir. It then passes through the inside of the armature to get to the gearing.

This lubrication system has given complete satisfaction.

Mr. Wallis. — In the American locomotive shown in figure 15, of the report from America, all the bearings of the motors are fitted with forced lubrication supplied from the circulating pump. The gears are lubricated with grease. The pump is fitted at the end of the locomotive.

Mr. Parodi (in French). — The locomotives of the Swiss Federal Railways, like those of the Paris-Orleans, of the Brown-Boveri type, have outside gears and forced lubrication.

Mr. Wallis. — The pump to which I referred is also carried on the gear-shaft.

The President (in French). — We will now proceed to discuss Article 5.

Mr. Weiss (in French). — I think it will be well to sub-divide this article as follows :

A) Is it possible to decide from experience gained whether a drive by connecting rods or the direct drive should be adopted for high-speed locomotives?

B) Can these locomotives be fitted with carrying axles of the radial type (Bissel or Adams), and in such case what precautions have to be taken? (Load on the axle, method of restoring, etc.)

The President (in French). — The first portion of the question appears to me to be difficult of solution at present. I suggest that it should not be examined in detail. With regard to the second part, this deals with the advantage or otherwise of radial axles or bogies at the leading end of high-speed locomotives.

Mr. Weiss (in French). — It would be of interest to have figures relating to the permissible load per axle required by considerations of track maintenance. A load of 15 to 17 t. is not generally exceeded for steam locomotives, whereas the figures that I have received appear to show that this load has been exceeded in the case of electric locomotives.

We may conclude form the data obtained that even in the case of locomotives without a leading bogie, it has been possible to increase the axle load.

Mr. Bachellery (in French). — On the Midi Railway we have found no difference in this respect between electric and steam locomotives.

It appears, however, that it is possible to increase the load for electric locomotives because these are free from placing additional load on the track caused by the rocking movement.

Our B.-B. type locomotives that run at 90 km. (56 miles) per hour, carry 18 t. per axle without a leading bogie, and we have had no difficulty with them. In exceeding this speed, we have taken as a basis the experience gained by constructors of steam locomotives, and we have adopted leading bogies. We thus designed the type 2-C-2 locomotive with rigid frame and leading bogies for each direction of running.

Mr. Parodi (in French). — The Paris-Orleans Railway has thought it would be of interest to make systematic trials on the guiding of locomotives, and for this reason, amongst the trial locomotives on order, we have ordered one that is so arranged as to enable us either to have no pivot fixed to the bogie (ordinary restoring) or to have the pivot behind the second axle of the bogie, or even to have it over the centre of this axle. As this arrangement has been adopted for each bogie, it is possible to obtain nine different combinations taking account of the direction of running; only four or five of these are of interest. By this means we shall be able to compare the arrangements adopted, as arranged in the direction of running of the train, and determine which is probably the best from the point of view of stability.

The President (in French). — There is a difference between electric locomotives and steam locomotives. Electric locomotives are generally required to run in both directions which is not the case with steam locomotives. It is therefore possible for the latter to run with less restoring force on the trailing carrying axle than on the leading axle.

The experiments that will be tried on

the Paris-Orléans and French Midi Railway systems will be interesting in the sense that they will enable us to ascertain the influence of bogies at the front and rear of the locomotives.

Mr. Wallis. — On the Pennsylvania Railroad we have constructed a locomotive, shown in figure 15, to which I referred just now. This locomotive has a Bissel bogie at each end. We have tried it and compared it with steam locomotives, and have been able to find no difference so far as the service of the line is concerned. The track is not subjected to additional load. The locomotive that I have mentioned, is shown in figures 14 and 15 of the American report. I have here the result of trials made on this locomotive if anyone should desire to see them. The two ends of the locomotive are absolutely alike, with the sole difference that the Bissel at one end is connected to a single pair of driving wheels, and the Bissel at the other end to three pairs of driving wheels.

Mr. Bachellery (in French). — On the Midi Railway, we have some high-speed locomotives that are absolutely symmetrical, and we have found no difficulty in the nature of swaying motion. It is interesting to learn that the Pennsylvania Railroad is returning to symmetrical locomotives because this railway system held a directly opposite opinion twenty years ago. It had stated that the symmetry of arrangement of the axles on the electric locomotives was the source of secondary movements which might introduce considerable disadvantages.

Mr. Wallis. — My reply to Mr. Bachellery is that our original opinion was based upon a defective arrangement of the springs. If we had altered this arrangement, we should have cut at the root of the trouble. We did not thoroughly understand the cause of the difficulty, but we came later to the opinion held by Mr. Bachellery.

Mr. Japiot (in French). — It would be interesting to know why the Pennsylvania Railroad adopted 2-wheeled Bissels on high speed locomotives, whereas on steam locomotives they have 4-wheeled bogies.

Mr. Wallis. — On consulting figures 14 and 15, you will note that with a four-wheel bogie the distance from the leading pair of driving wheels to the centre of the bogie would be much greater which would result in a great increase in lateral play. This led us to adopt a Bissel bogie, which we have found to give perfect safety. The distance from the first pair of driving wheels to the centre of the bogie pivot would have been very large; we therefore tried the type of bogie at present in use, and experience has shown this method to be right. I have here the results of trials up to speeds of 75 miles per hour, and I shall be pleased to show these to Mr. Japiot if he desires to see them.

Mr. Weiss (in French). — The locomotives of the Swiss Federal Railways have an asymmetric arrangement (2-C-1) on account of the weight of the transformer which is at one side. These locomotives run perfectly in both directions.

With regard to restoring the bogies, laminated springs only were used at the commencement, but this system caused shocks on curves of small radius (points). It was necessary to increase the restoring force by adding volute springs. There is a certain amount of play between the two spring systems, so that the supplemen-

tary restoring force of the volute springs is not immediately brought into action.

Mr. Parodi (in French). — I wish to recall an experiment made by Mr. Weiss with a locomotive having a bogie in front and a Bissel bogie at the rear on the line from Berne to Thun, at the speed of 62 to 65 miles per hour. The running in both directions was perfect. This fact is of interest, and proves that, provided the calculations have been made correctly any arrangement that may be adopted can give complete satisfaction.

Mr. Leboucher (in French). — There is another interesting point which it is important to raise. It is the height of the point at which the force is exerted by the bogies. If the point at which the force exerted by the bogies upon the body lies in the horizontal plane through the centre of gravity, the movement transmitted will be a swaying; if on the other hand the point of application of the force is below that plane, the movement transmitted will be a rocking movement. Examination of this question has great importance with regard to stability. If the point of application is low, the body leans over, and the restoring force is smaller than if the whole of the body has to be displaced. It would appear from the point of view of stability to be necessary that the point of application of the force exerted by the bogies should act on the body as low down as possible.

The President (in French). — This question has been examined theoretically outside the Congress, and I think that a reexamination would take up too much of our time. We should confine ourselves to recording practical results. Can any delegates give particulars of experiments that confirm the opinion of Mr. Leboucher?

Mr. Leboucher (in French). — The experiments that we have made on our railway system confirm that it is of importance that the force exerted by the bogies should be applied as low as possible, so that the locomotive may rock slightly. This observation is particularly applicable to locomotives having a leading bogie.

The President (in French). — From the discussion that has taken place, it would appear possible to draw the two following conclusions which I would ask you to consider :

For electric locomotives at speeds up to 56 to 62 miles per hour it has not been considered essential to arrange a leading bogie or radial axlebox.

For locomotives running at very high speeds, it does not appear that the bogie is essential. Several Companies have found that the Bissel bogie gives equal satisfaction to an ordinary bogie.

Before adjourning the meeting, I suggest that the discussion on Article 9 should be commenced.

Mr. Bianchi (in French). — With locomotives running at very high speeds we have obtained an annual distance run of 75 000 miles. With steam locomotives, we only obtain the figure of 37 500 miles per annum, that is to say, one-half the distance.

The President (in French). — Is that an annual distance run, and not a distance run between successive overhauls?

Mr. Bianchi (in French). — The figures are identical because a general overhaul is made at approximately yearly intervals.

Mr. Bachellery (in French). — The experiments that we have made absolutely

confirm what Mr. Bianchi has just said. A steam locomotive generally runs in a day over the distance that can be managed by a single crew; on the other hand, the electric locomotive can go much further, and in the day it can run a distance corresponding to the work of several crews, at any rate of two. These are the conditions that enable actual working with electric locomotives to double the distance run by steam locomotives per annum.

Mr. Rivet, Ministry of Public Works, France (in French). — Could not Messrs. Bachellery and Bianchi state whether from the point of view of output, the electric locomotive can replace two steam locomotives?

Perhaps Mr. Weiss could also tell us whether, in Switzerland, the electric locomotives which are largely used give a similar result?

Mr. Weiss (in French). — The difference that has been found in Switzerland is not very great. Account must be taken of the fact that the services worked by the steam locomotives and by the electric locomotives are not similar. In Switzerland it has always been the custom to run the steam locomotives with two or three crews, which will explain why the distance run by these high-speed locomotives compare very closely with those run by the electric locomotives.

The annual mean distance run by steam express locomotives is about 43 000 miles, and for electric locomotives 40 000 miles per annum.

The railway system has still a number of lines on which steam locomotives are run, and this has enabled us to obtain an annual mean figure for these locomotives that is slightly greater than that obtained from the electric locomotives. This is not, however, the case on the Gothard Line, which is electrically equipped and has a considerable length. The mean distance obtained for the electric locomotives running on this line amounts to 61 000 miles. I think it is possible to deduce from our experience that the difference in distance that can be run by electric and steam locomotives is not great provided that the services of both classes of locomotive are arranged in a similar manner. In Switzerland we have always tried the method of making the locomotives cover as great a distance as possible. This is probably the explanation of the larger figures given for our mean distances run.

The President (in French). — It would appear to follow from the somewhat discordant data that have been given, particularly for the Italian and Swiss railways, that the mean distances run by the locomotives depend on two factors : the number of crews and the length of the runs.

If the runs are rather short, the working resembles that of the outer suburban services. This confirms the results obtained on the Alsace-Lorraine railway system, on which it has not been found possible to adopt the method of working by two or three crews.

Mr. Renevey, Alsace-Lorraine Railway (in French). — A piece of information which would be of use, but which Mr. Weiss may not perhaps be able to give us immediately, is the number of days per annum on which the electric locomotives cannot be run.

Sir Henry Fowler, London Midland & Scottish Railway. — Before leaving the question of the distance run by the locomotives between two shoppings, I should like to say that the figure given by

Mr. Bianchi, which I think was 20 000 miles, should be multiplied several times before it will correspond to the actual results that we are obtaining. I have not the figures with me, they vary, of course, with the division of the line and the service it carries. But as I have mentioned, it would be necessary to multiply the distance given by three or four in order to arrive at what we consider a satisfactory result.

The President. — Mr. Bianchi spoke of 75 000 miles in the case of the electric locomotive, and 37 500 miles in the case of the steam locomotive, per annum. Have you the comparative figures?

Sir Henry Fowler. — No, I have not got comparative figures. I thought that the figures quoted represented the distances run between shoppings.

Mr. Bianchi (in French). — Yes, they can also be taken in this way because we carry out light repairs almost every year, but we do not do the same for general overhauls.

Sir Henry Fowler. — I have not the figures with me, but the distance of 37 500 miles, given by Mr. Bianchi as that run by a steam locomotive between two shoppings, is much too small from the English point of view.

The President (in French). — This depends on what is understood by a « shopping ».

Sir Henry Fowler. — Absolutely. May I also say that this depends on the water used?

The President (in French). — What is meant in this case is removing the wheels, replacing the tyres, and so on, but not making any boiler repairs.

Mr. Wallis. — The first 33 electric locomotives destined for the Pennsylvania Railroad, were constructed in 1910. The wheels, tyres, etc., are repaired regularly as in the case of steam locomotives; but the maintenance of the electric portions is practically nil. Out of the 33 locomotives, we have only rewound four or five since 1910.

The President (in French). — What was the distance run between overhauls?

Mr. Wallis. — I cannot state definitely as I do not know, but it is a very great distance.

The President. — 62 000 miles.

Mr. Wallis. — It is much less between repairs to wheels, tyres, etc., but when it concerns the motors it is appreciably greater because most of them have been running in service since 1910.

The President (in French). — I think it would be well to confine ourselves to the question of the maintenance of the electric motors, leaving aside everything relating to the maintenance of the mechanical portion.

Considering the hour, we will adjourn the meeting and continue the examination of the question of the distances run by the locomotives when we go into that of the maintenance of the motors.

— The meeting adjourned at 12 o'clock.

Meeting held on 26 June 1925 (afternoon).

Mr. WEISS, PRESIDENT, IN THE CHAIR.

The President (in French). — We will now continue the discussion on electric locomotives.

The discussion on Article 9 has not been closed, but I think it will be preferable to begin directly with the discussion on Article 6.

« Has it been found that the presence of the oil necessary for the circuit breakers used with alternating current or with the transformers gives rise to any danger in working? In that event, have any steps been taken to prevent risk? »

Mr. Bianchi (in French). — We have found in Italy that the presence of this oil on the locomotives constitutes a danger; we have had several burst circuit breakers.

Mr. Steiner, Swiss Federal Railways (in French). — The presence of oil in the transformers and in the circuit breakers certainly forms a risk of accident.

There are two methods for guarding against this : the one consists in keeping accurate statistics, which serve in searching for and finding the weak points in these appliances in order to make all possible improvements in them.

On the Swiss Federal Railways these weak points, according to our observations, are as follows :

In the circuit breakers too little distance between the part at which the spark occurs and the earth;

in the transformers, the use of hygroscopic insulating materials for the windings, which insulating materials in damp weather absorb the small quantity of water in suspension in the oil, and may thus be the cause of serious damage .

It has been endeavoured to avoid these disadvantages :

in the circuit breakers, by increasing, whenever possible, and as far as possible, the distance from earth. The shock resistances which had the shortest distances were abolished after numerous trials and the interior of the tanks insulated;

in the transformers, by impregnating the windings with special lacquers that eliminate the hygroscopic power of the cotton used;

the other method consists in using air-insulation circuit breakers but this question,although it has been a long time under investigation, is far from being solved — and air-cooled transformers without an oil-bath. The question as to whether this last system does not offer other serious disadvantages has, however, not yet been examined. It will be interesting in this respect to obtain some particulars from companies in America where the use of air-transformers is, I know, more extensive than in Europe.

Mr. Wallis. — We have examined this question, but I do not think it is nearer to a solution in America than in the country of the last speaker. We are not sure that we have found a solution up to the present. The New York, New Haven & Hartford Railroad have the largest number of appliances of this kind. On the Pennsylvania Railroad we have oil transformers and oil circuit breakers, but we are not sure that they have been properly installed. We have not yet a suf-

ficient number of locomotives to enable us to gain the necessary experience for designing a final model.

The President (in French). — With a single exception, the Swiss Federal Railways use only oil transformers. It has therefore not been possible to make comparisons; I should like, however, to mention that up to the present we have only had a single accident with the oil transformers, and this was not on a high-speed locomotive.

Mr. Wallis. — I should say that this question has not actually arisen in the United States either. It was investigated by the Pennsylvania Railroad, but I do not think it has received any general attention in the United States. Nobody has objected to the arrangements in use up to the present. So far as I am aware, no high authority or railway officer has objected to the oil transformer.

The President (in French). — I can inform the meeting that in Germany both types of transformer are in use in almost equal numbers.

I think that the discussion may be considered as sufficient, and that we may proceed to discuss Article 7.

« What is the type of remote control that has given the best results up to date (electric, electro-pneumatic, mechanical, etc.)? »

Mr. Bianchi (in French). — On the Italian Railway system we use mechanical, pneumatic and electro-pneumatic controls. The latter give the better results.

Mr. Wallis. — In the United States, electric and electro-pneumatic controls are used, and I believe with the same results as in Italy.

Mr. Leboucher (in French). — On the Midi Railway an electric control has been adopted which is controlled mechanically by a camshaft. This solution, which at first sight appears very attractive, has however caused some trouble, because the camshaft that operates the contactors cannot be turned backwards unless a strong blow-out is fitted to each contactor. If these blow-outs are so arranged, the space taken up becomes very great. The power of the balancing current does not allow the blow-out to be dispensed with, and it is then necessary to cut off the current at a single operation. It changes consequently from the normal amperage to zero. This sudden jump produces excessive rise of voltage which disturbs the system. We hope to use the electro-pneumatic system for our new locomotives.

Mr. Steiner (in French). — The Swiss Federal Railways have had the opportunity of testing most systems. The contactor system appears to have proved satisfactory. It has, however when the control is entirely electro-pneumatic, a weak point : this is in the locking of the contactors.

Mr. Parodi (in French). — On the Paris-Orleans Railway system on the 200 locomotives that run up to 50 miles per hour, and on a certain number of high-speed locomotives, we have used the electro-pneumatic system. We had previously made trials of the electro-magnetic control, but we thought that it was better from the point of view of safety and of regularity in running to use the electro-pneumatic system.

The system has separate contactors and the camshaft is driven by a pneumatic servo-motor. We use magnetic blow-outs.

The President (in French). — We will now proceed to discuss Article 8.

« To what figure has the maintenance of a continuous current motor and an alternating current motor been reduced? What mileage has been found possible without examination being required more than once a day? »

Mr. Bianchi (in French). — The maintenance of three-phase motors consists in looking after the centring because the air gap must not exceed 1.5 mm. (1/16 inch.).

With regard to the windings, there is no need for maintenance if the motor is well constructed. We still have motors that have done 20 years' service without repair to the windings. If the construction is not carefully carried out, the result is quite different.

Mr. Wallis. — In the United States we think that the maintenance of motors using simple alternating current as compared with direct-current motors, is slightly more costly, but our experience relates to cars rather than to locomotives. The only experience that we have had with single-phase motors is that of the New York New Haven & Hartford Railroad, which has found that the cost of maintenance is not much higher than that of direct current locomotives.

Mr. Steiner (in French). — The use of single-phase motors is not yet in general favour because of the difficulty of maintenance and special care that appears to be required.

But if they are carefully made and their peculiarities are kept in mind, the cost of this work may be considerably reduced.

We make a distinction between two kinds of maintenance :

general maintenance, and
maintenance of the brushes.

As regards general maintenance, single-phase motors, in my opinion, require nothing more than direct-current motors:

inspection of the brushes every 3 weeks and slight cleaning of one part or another in case it is required,

in addition, complete examination of the motor including testing the insulation of the windings every 6 months.

The maintenance of the brushes, on the other hand, at present, gives use to some difficulties, on account of the wear of the segments of the commutator and of the necessary truing by grinding after a certain mileage according to the type of locomotive; this mileage at present varies between 30 000 to 95 000 miles.

We hope, however, that in course of time, with skill, the cost of this maintenance will be reduced and the single-phase motors will not show any greater disadvantages in this respect than direct-current motors.

Mr. Parodi (in French). — The question of maintenance of traction motors is a function of the construction of these motors.

I think — and I shall welcome any difference of opinion on this subject — that the construction of motors instead of improving from the point of view of manufacture, is actually becoming worse. The motors are better designed, but the workmanship from the constructional point of view is not so good as it was twenty years ago. On the line from Paris to Juvisy there are motors that have never required the slightest repair up to the time when, as the result of a flood,

they required to be reconstructed. I should not dare to say that the motors that have been delivered to us during the last ten years will last as long. They are frequently under repair.

In the case of the new locomotives that we are having built in quantity, we have had struggles, which I may term violent, with the manufacturers in order to compel them to work to specification.

The President (in French). — It would be of interest to hear, with regard to this, the opinion of those companies that have had motors in service for a long time.

Mr. Bianchi (in French). — We have had direct-current motors, dating from 1900, that are still running well; this is the best type of motor we have at work.

The President (in French). — From what we have heard, we must infer that modern motors are not so well constructed as the old motors.

Mr. Bianchi (in French). — The modern motors are too light, too hard driven, and have forced ventilation. They run well unless the ventilation is stopped, when they must be put out of action, whereas the old motors could run even under very bad conditions.

Mr. Wallis. — I think that in America there is also a tendency to construct, for a given power, a smaller motor than that which was usually supplied ten years ago.

The President (in French). — We will now commence the discussion on the first portion of Article 9.

« What is the present mean distance run by electric high-speed locomotives as compared with steam locomotives of the same class? »

It has been already stated this morning that the differences found in the distance run may arise from the methods adopted for using the locomotive. Steam locomotives are not placed in the hands of any driver in the same way as the electric locomotives.

Mr. Bianchi has said that on his railway system the electric locomotives run up to 75 000 miles. Can he explain this figure? Is it not exceptional?

Mr. Bianchi (in French). — It is evidently a question of an exception. During the first years we had not a sufficient number of locomotives on the Turin-Milan line. Those locomotives that were available had to run distances of 75 000 miles, but it was found that it was not possible to maintain this figure on account of the times of running of the trains, and also because of other requirements of the service, particularly of traction and of displacement of the staff.

Mr. Parodi (in French). — In the trials made on the Paris-Orleans line on the suburban service, we found that it was possible to double the distance run by the electric locomotives as compared with steam locomotives. The comparison was made on two lines with almost identical traffic.

We were unable to make the same trials on main lines. It follows, however, from the trials that we have made, that on these main lines we shall arrive at ratios of mileage analogous to those given above, only when the length of the electrified lines will amount to 185 to 250 miles.

Mr. Wallis. — In the United States the steam locomotives run up to 500 miles on a single run. On the electric lines the present position is in no way similar, so that our experience up to the present does not show what will be the ultimate distance run by electric locomotives per

month. All those who reckon on electrifying their lines, expect a monthly mileage at least 30 % greater than that which would be obtained from steam locomotives in normal service.

Mr. Renevey (in French). — Can the President tell us whether in Switzerland, the service is worked with a double crew, or whether any crew works any locomotive?

The President (in French). — The service is worked in exactly the same way usually with two or three crews on electric locomotives and on steam locomotives.

On the Gothard Railway, where the line is very difficult and high speed cannot be maintained, the service is continued day and night. Some electric locomotives have run more than 9 300 miles per month.

It would not be possible to obtain such results with steam locomotives. A figure of 6 200 to 7 500 miles could only be exceeded with difficulty.

It is very difficult to make exact comparisons on other lines. The electrification of the railway system is not yet so far advanced that it is possible to carry on rational services over long-distance runs. For this reason, the steam locomotives at present run a mean mileage that is greater than the electric locomotives.

Mr. Wallis. — I am informed by Mr. Withington of the New York New Haven & Hartford Railroad, who is seated here, that on his railroad all the electric locomotives run a mean distance of 200 miles per day, and one locomotive runs up to 500 miles per day.

The President (in French). — We must be careful in making these comparisons. In Switzerland we have lines on which there are not a sufficient number of electric locomotives. They do not suffice for the whole of the traffic. The best trains are hauled by electric locomotives, and the other trains, some of which stop at each station, are hauled by steam locomotives. Under these conditions it is not possible to make a comparison between the two services.

A very interesting question was put just now, asking how long the locomotives remain in the repair shops.

Mr. Bianchi (in French). — We have electric locomotives that have run for two years without repair; others have undergone repair every six months. The three-phase locomotives generally stay in the workshops 30 days in the year (for large and small repairs; connecting rods and mechanical details).

The direct current locomotives with connecting rods require much simpler maintenance; the air-gap is several millimetres wide.

With regard to the electric portion of these locomotives, it may be said that if nothing serious happens the locomotives can go on running; otherwise, it is a case of complete overhaul. We have motors that have been in service 15 to 20 years without any repair; others, badly made, required repair after two or three months. We have found, moreover, that locomotives that have not been running in regular service require more repairs than the others in the electric equipment.

Mr. Renevey (in French). — It would be very interesting to have the opinion of the Swiss Federal Railways regarding the number of stand-by locomotives and the cost of standing locomotives. Has this railway system found an appreciable difference between the proportion of

electric locomotives and of steam locomotives kept standing? Is the number of stand-by locomotives less in one system or in the other?

The President (in French). — It is rather difficult to answer this question. We can make no exact comparison on this subject. Many of our lines have mixed traction; on some of these we have at certain times a surplus of a few electric locomotives; but when a new section of line is electrified, the number of locomotives at our disposal becomes insufficient. Under these conditions, attempts are made to make the electric locomotives cover as great distance as possible, while keeping a number of locomotives in reserve.

Mr. Renevey (in French). — It would be of interest to know the percentage of locomotives under repair. On the Alsace-Lorraine Railway we made a return of the number of locomotives that could not be put into service under 24 hours. We found that the mean daily figure was 10 to 12 %.

The President (in French). — Unfortunately, I have not these figures here. We have made the return of which you speak, and I can state definitely that the figures are more favourable for the electric locomotives. The case is quite different when it is a question of small maintenance jobs. This may have something to do with the newness of the system, and I feel certain that in time this will no longer be the case.

We will now proceed to discuss the second portion of the article :

« Are any steps being taken for operating electric locomotives by a single man, and if so, under what conditions? »

Mr. Bianchi (in French). — In Italy we have direct current locomotives, driven by a single man and fitted with a dead-man switch.

As, on these locomotives, the driver has sometimes to leave his lever to see how the train is running, we have devised a special arrangement that allows the driver to release the switch lever for one minute. If the driver has not returned to his place within the minute, the dead-man switch comes into operation and applies the brakes. This system has not yet been applied, but we expect to use it on high-speed locomotives.

Mr. Barnet-Lyon, Ministry of Waterstaat, Holland (in French). — The driving of an electric locomotive is a sufficiently simple matter to require only a driver, but it should be noted that on main lines the driver has also to look out for signals. It appears, therefore, that the presence of two men on the locomotive is necessary for looking after other services than the driving of the locomotive.

Mr. Parodi (in French). — On some of our suburban lines, we have only one man driving. We have constructed locomotive-vans and the guard travels in the van. On the new locomotives being constructed, to work at 1 500 volts, in which the whole of the central portion of the body is occupied by the driving gear, we could not make an arrangement for the guard to ride on the locomotive itself. Although these locomotives can be driven by a single man, we are running them with two men for the time being.

Mr. Wallis, *Reporter*. — In the United States we have always two men on electric locomotives, but on motor cars we have only one.

Mr. Gresley, London & North Eastern Railway. — The practice in England is

the same as in America. We have two men on electric locomotives, but on motor vehicles we have one man only.

The President (in French). — Do you not think you will have a single driver for the locomotives?

Mr. Gresley. — We have not tried this at all. We have not tried the dead-man's handle for locomotives.

The President (in French). — On the Swiss Federal Railways, there have always been two men on the locomotives and one man on the motor vehicles. The latter are fitted with two combined «dead man» switches. There are a dead-man hand-switch and a pedal. If the driver releases either of these the main circuit-breaker is opened and the air-brake applied automatically when a certain speed, about 12 miles an hour is exceeded.

It appears to me that the discussion on this Article is now completed. It will be necessary that the wording of the article should be modified, and we will postpone the examination of this text to our next meeting on Monday.

— The meeting adjourned at 5 o'clock.

Meeting held on 29 June 1925 (morning).

Mr. WEISS, PRESIDENT IN THE CHAIR.

— The meeting opened at 9.30 a. m.

The President (in French). — On Friday last, we finished the general discussion of Question V, relating to high speed electric locomotives. It remains for us to day to settle the final summary.

(*The President continuing in English.*) — The following is the first paragraph of the proposed summary drafted by the reporters :

« 1. — The two systems of transmission, the « tram » and the « gearless », can be used on high-speed locomotives and run well. It is, however, necessary, on account of the non-sprung weight and of the relatively low position of the centre of gravity, to reduce the load per axle within reasonable limits. »

Mr. Lacoin, Paris-Orleans Railway (in French). — I propose to replace the words « it is, however, necessary », by « it has been found advantageous ».

The President (in French). — So far as I am concerned, I accept Mr. Lacoin's proposal. (*Carried unanimously.*)

Mr. Japiot (in French). — Before proposing to reduce the weight in the case of the « gearless » transmission, it will require to be shown that this reduction is necessary.

(*Continuing in English.*) — I think that it is dangerous to insert a clause stating that it is advisable to reduce the axle load. No particulars have been received that prove this to be actually necessary. The permanent-way engineers might take up a position adverse to this type of locomotive if the paragraph were so worded.

The President (in French). — This question was discussed and agreed at the meeting on Friday last. I would remind you also that the load per axle has been increased up to 35 t. in America, and

that the « gearless » locomotive has much less axle load than the connecting-rod driven locomotive. We must not go too far in this direction.

Mr. Japiot (in French). — It would perhaps be well that what would appear a reasonable limit should be given. I am afraid that the permanent-way service will take our figures and ask for a limit of 10 to 12 t. There is a large difference between 35 t. and 10 t. It appears to me that a limit of 20 t. would be admissible.

Mr. Tchéou Weï, Chinese State Railways (in French). — What is the exact text under discussion? Is it paragraph 5?

The President (in French). — We are discussing the question of weight, but it will be difficult to introduce figures into the summary.

Mr. Japiot (in French). — It would be possible to invert the phrase and say : « It will not be possible to attain such great loads. »

The President (in French). — I propose to delete the words « as far as possible ».

Mr. Bachellery (in French). — Instead of « reduce the load » we might say « keep the load within reasonable limits ». (*Agreement.*)

— Paragraph 1, was adopted as amended.

The President (in French). — We have now to consider the text of the second paragraph. This is the suggested wording :

« The Westinghouse drive may be and is used on high-speed locomotives. The concentricity of the driving axle and the hollow shaft should be maintained as nearly as possible constant. The advantages of this class of drive diminish as the number of axles in the train increases. »

Mr. Bachellery (in French). — I think that it is not advisable to introduce the name of a firm into our summary. I propose that we replace the words « Westinghouse drive » by « drive by hollow shaft?

Mr. Tchéou Weï (in French). — I support the remark put forward by Mr. Bachellery. I think that it would be better not to mention an individual firm, and thus avoid our giving the impression of a monopoly or of a marked preference.

The President (in French). — Are we in agreement that the words « Westinghouse drive » should be replaced by « drive by hollow shaft ». (*General expression of approval.*)

This will be adopted.

Mr. Japiot (in French). — I think that the wording of this statement is not very happy. You say « the concentricity of the driving axle and of the hollow shaft should be maintained ».

We do not quite grasp the bearing of this finding.

The President (in French). — We say : « as far as possible ».

You know that if concentricity cannot be maintained between the driving axle and the hollow shaft, fracture of the springs may easily be caused.

Mr. Lacoin (in French). — Generally speaking, there is agreement. It is merely a question of wording.

Mr. Japiot (in French). — I propose the following reading :

« The hollow shaft and driving axle

should be kept as concentric as possible. »

The President (in French). — The English text is correct.

Mr. Japiot stated that the change only concerned the French text.

Mr. Wallis. — I wholly approve this amendment of the French text, which appears to me better than the English text.

Mr. Bachellery (in French). — I do not see the reason for the last phrase : « the advantages of this type of drive diminish with the increase in the number of axles carrying the frame. »

The President (in French). — Suppose there are ten axles; it will be impossible to obtain constant concentricity between the axles and the hollow shaft, because the track is never perfect. Now, the greater the deviation from concentricity, the larger will be the number of fractures of springs produced.

Mr. Bachellery (in French). — It is a rare case for ten axles to carry the same frame.

The President (in French). — We are in agreement.

Mr. Bachellery (in French). — It appears to me that this finding is merely a consequence of the preceding one. I ask whether it will not suffice to add to the first finding the following phrase :

« This condition becomes more difficult to obtain the greater the number of axles carrying a single rigid frame. »

The President (in French). — The expression « rigid frame » does not meet the question. The rigid frame would only comprise the driving axles, in the usual sense of the term, and would not apply to all the axles carrying a single chassis, if there were a pair of leading carrying wheels, for example, in the case of a locomotive of the 2-8-8-2 type.

Mr. Wallis. — But the other axles have not hollow shafts, and there is no need to take account of them. It is only the driving axles that have hollow shafts.

The President (in French). — Will you accept the words « in the same chassis »?

Mr. Wallis. — I do not see any objection.

The President (in French). — I think that we are in agreement on the following wording :

« 2. — The drive through the hollow shaft may be and is used on high-speed locomotives. The hollow shaft and the driving axle should be maintained as closely concentric as possible. This condition is the more difficult to realise the greater the number of axles carried on any particular rigid frame. »

— This text was put to the vote and adopted.

The President (in French). — We will now go on to the following paragraphs :

« 3. — It is desirable in the case of high-speed locomotives driving through connecting rods, to arrange an elastic transmission system. The adjustment of the connecting rods should, however in all cases be very carefully examined. »

— Adopted.

« 4. — Various types of gearing with oil or grease lubrication are at present in use on high-speed locomotives. In general, they give satisfactory results. »

— Adopted.

« 5. — The small amount of experience acquired up to date does not permit us to recommend definitely either the connecting-rod form of drive or the direct drive.

« Each of these systems is at present in use.

« The equipment of locomotives with carrying axles or bogies appears to be only necessary in the case of very high-speed locomotives. »

Mr. Wallis drew attention to the fact that the English text says : « or drive by gearing », instead of « direct drive ».

— Paragraph 5 was adopted.

« 6. — The use of the oil circuit breaker and of the oil transformer appears to be general in the equipment of high-speed locomotives using alternating current; they do not appear to have given rise to serious difficulties up to the present time. »

— Adopted.

« 7. — Of the various systems of control used on high-speed electric locomotives, the electro-pneumatic appears to give the most favourable results. »

Mr. Bianchi (in French). — I propose to delete the words « high-speed ».

The President (in French). — I am also of opinion that these words may be deleted without disadvantage.

Mr. Tcheou Wei (in French). — I had intended to make the same suggestion, because the construction of the locomotives is not uniform.

The President (in French). — Is the meeting agreed on deleting the words « high-speed »?

— General expressions in the affirmative.

The President (in French). — Paragraph 7 is accordingly adopted, with the deletion of the words « high-speed ».

« 8. — The relatively recent introduction of electric traction by high-speed locomotives does not enable the cost of maintenance of the different types of motors to be obtained at present. They appear, however, not to present very great differences. »

— Adopted.

« 9. — The various methods of working the large railway systems by steam traction and electric traction with high-speed locomotives do not at present permit a definite comparison to be made between the distances run by each. It appears, however, from the short experience obtained and from calculation that electric traction should present an advantage over steam traction. »

— Adopted.

« 10. — The driving of high-speed electric locomotives by a single man with or without safety appliances is not at present adopted. The question is, however, being examined in various countries. »

Mr. Lacoin (in French). — I propose that we say : « Of very high-speed electric locomotives. »

(*Mr. Lacoin continues in English*) : I propose to say « very high-speed », in order that the finding may not cause difficulty to some railways on which the distinction between high-speed locomotives and fast locomotives is not easy to draw.

The President (in French). — We have no definition of a « very high-speed locomotive ». In our reports, however, it is stated that a high-speed locomotive is one that runs at more than 47 miles per hour.

Mr. Bachellery (in French). — It is because the limit has been fixed at 75 km. per hour that I support the suggestion of Mr. Lacoin.

The President (in French). — I do not clearly see why it should be necessary to say « very high-speed locomotives », because there is no high-speed locomotive at the present time driven by a single man.

We have confined ourselves to saying that the question is under consideration. I think we can all accept the proposed wording; it ties nobody, and leaves the question open.

Mr. Lacoin (in French). — On two French railways, the goods locomotives are capable of running at speeds of more than 75 km. per hour. We intend to run them, under certain conditions, with one man only. If we keep to the proposed wording, the objection may be raised that locomotives running at more than 75 km. per hour are very high speed locomotives, and that we cannot entrust the driving to a single man.

I therefore adhere to my proposal.

The President (in French). — This wording could not be used to prevent a company from running high-speed locomotives driven by a single man. It leaves everyone freedom of action. I do not quite understand Mr. Lacoin's objection.

Mr. Nobili, Italian State Railway (in French). — As no definition has been given of « high-speed », Mr. Lacoin's proposal does not apply. It leaves the question as it was, because there is no definite beginning or end for high-speed.

It appears to me simpler to adhere to the proposed wording.

Mr. Wallis. — I propose that in our summary, we delete all reference to the number of employees driving locomotives, whether at high-speed or at low speed. On many American railways, automotor vehicles driven by a single man, run at speeds up to 68 miles per hour. It appears that our summary should not refer to the number of employees driving the locomotives. This is really a question of the staff, and not of the technical organisation, and I ask that the paragraph shall be deleted.

The President (in French). — Are we agreed to suppress the paragraph? (*Yes, yes.*)

As there is no opposition, the 10th paragraph is deleted.

The President (in French). — We have completed our discussion of the findings which have been drafted as follows :

« 1. — Both the « Tram » and the « Gearless » types of transmission can be used for high-speed locomotives, and give good running. It has, however, been recognised that in view of the unsprung weight and of the comparatively low height of the centre of gravity, the axle load should be kept within reasonable limits.

« 2. — The hollow shaft, (or quill) drive can be and is used on high-speed locomotives. The hollow shaft and the driving axle should be kept as nearly as possible concentric. This condition becomes more difficult to realise, the greater the number of axles running in the same rigid frame.

« 3. — In the case of high speed locomotives, driven by means of connecting rods, it is desirable to provide elasticity in the transmission system. The adjustment of the connecting rods should, however, be carefully checked.

« 4. — Various systems of gearing, lu-

bricated by oil or by grease, are at present in use on high-speed locomotives. These systems generally give satisfactory results.

« 5. — The small amount of experience that has been gained up to the present time, does not permit of making a definite recommendation relating to the connecting rod drive or the direct drive.

« Both these systems are at present in use.

« The equipment of locomotives with carrying axles or bogies appears to be only necessary in the case of very high speed locomotives.

« 6. — The use of the oil circuit breaker and of the oil transformer appear to be generally adopted for the equipment of high-speed alternating current locomotives; up to the present time they do not appear to have given rise to serious difficulties.

« 7. — Of the various control systems used on electric locomotives, the electropneumatic appears to give the most satisfactory results.

« 8. — In consequence of the relatively recent date of the introduction of electric traction by high-speed locomotives it is not possible at present to compare the costs of maintenance of the various types of motors. They do not, however, appear to show very great differences.

« 9. — The various methods of working large railway systems by steam and by electric traction, with high-speed locomotives, do not at present allow any definite comparison to be made between the mileages run. From the short experience obtained, and from the results of calculation, it appears, however, that electric traction should present an advantage over steam traction. »

The President (in French). — Are there any further remarks to be made?

As there are no further remarks, I will put the final summary to the vote, in the terms which I have just read.

— The summary was adopted.

— The meeting adjourned at 11.25 a. m.

DISCUSSION AT THE GENERAL MEETING

Meeting held on the 1 July 1925 (afternoon).

PRESIDENT : THE RIGHT HON. Sir EVELYN CECIL, VICE-PRESIDENT.
GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. GHILAIN.

Sir Henry Fowler, *General Secretary*, read the summary adopted by the 2nd section. This final summary gave rise to no discussion.

The President. — The final summary is therefore as follows :

Final summary.

« 1. — Both the « Tram » and the « « Gearless » types of transmission can « be used for high-speed locomotives, and « give good running. It has, however, « been recognised that in view of the un- « sprung weight and of the comparati- « vely low height of the centre of gra- « vity, the axle load should be kept within « reasonable limits.

« 2. — The hollow shaft (or quill) « drive can be and is used on high-speed « locomotives. The hollow shaft and the « driving axle should be kept as nearly « as possible concentric. This condition « becomes more difficult to realise, the « greater the number of axles running « in the same rigid frame.

« 3. — In the case of high-speed loco- « motives, driven by means of connecting « rods, it is desirable to provide elasticity « in the transmission system. The ad- « justment of the connecting rods should « however, be carefully checked.

« 4. — Various systems of gearing, « lubricated by oil or by grease, are at « present in use on high-speed locomo- « tives. These systems generally give sa- « tisfactory results.

« 5. — The small amount of experience « that has been gained up to the present « time, does not permit of making a de- « finite recommendation relating to the « connecting rod drive or the direct « drive.

« Both these systems are at present in « use.

« The equipment of locomotives with « carrying axles or bogies appears to be « only necessary in the case of very high- « speed locomotives.

« 6. — The use of the oil circuit « breaker and of the oil transformer ap- « pear to be generally adopted for the « equipment of high-speed alternating « current locomotives; up to the present « time they do not appear to have given « rise to serious difficulties.

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« types of motors. They do not, however, appear to show very great differences.

« 9. — The various methods of working large railway systems by steam and by electric traction, with high-speed locomotives, do not at present allow any definite comparison to be made between the mileages run. From the short experience obtained, and from the results of calculation, it appears, however, that electric traction should present an advantage over steam traction. »

— The final summary was adopted by the General Meeting.

[621 .138 & 725 .33]

QUESTION VI.

LOCOMOTIVE SHEDS.

Arrangement of locomotive sheds.

Installations :

a) *for inspecting engines;*
b) *for washing out boilers and blowing through the tubes;*
c) *for lighting up of engines and getting rid of the smoke;*
d) *for loading fuel on the engines. Mixing fuels. Disposal of ashes;*
e) *for the recovery of coal and coke from the residues of combustion.*

Preliminary documents.

1st report (British Empire), by Mr. R. E. L. MAUNSELL. (See English edition of the *Bulletin*, February 1925, p. 501, or separate issue [with red cover] No. 21.)

2nd report (all countries, except the British Empire and America), by Mr. G. FORTE. (See English edition of the *Bulletin*, May 1925 [1st part], p. 1561, or separate issue [with red cover] No. 39.)

3rd report (America), by Mr. R. W. BELL. (See English edition of the *Bulletin*, March 1925, p. 765, or separate issue [with red cover] No. 28.)

Special reporter : Mr. G. FORTE. (See English edition of the *Bulletin*, June 1925, p. 2115.)

DISCUSSION BY THE SECTIONS

Meeting held on 30 June 1925 (morning).

SECTIONS I AND II (MEETING JOINTLY).

Mr. E. F. C. TRENCH, C. B. E., PRESIDENT OF THE 1st SECTION, IN THE CHAIR.

— The meeting opened at 9.30 a. m.

The President. — I have been asked to take the chair at this joint meeting of sections 1 and 2 by Mr. Weiss; and in doing so I should like to point out one or two difficulties which we are faced with this morning. The subject of locomotive sheds is of course a wide one, and one on which there are differences of opinion; and the task of the Reporter has in this case been rendered very difficult owing to the fact that the various reports have not been drawn up all on similar

lines. As you know, in previous meetings we have had concise statements which we have been able to discuss, and either accept, amend or reject. In this case it is not so for the reason I have just given and consequently our programme is rather indefinite. We shall have to go through the general summary of the papers, and endeavour to arrive at some useful conclusions. In order to do so, I think we shall be saving time if we avoid discussion on the actual material of which the locomotive shed is to be constructed. It seems to me to be immaterial whether a shed is built of concrete, of brickwork, or of masonry, or roofed with slates or concrete or other material. The choice may very well be left to the discretion of the engineer who has the task of preparing the designs for the shed. What we do want to know are the essential features the Locomotive Running Department require, and what are the varying circumstances which have to be taken into account in arriving at a decision as to the proper form of the shed, the proper equipment of the shed, the arrangement of the stores, the housing of the staff, and all the other varying factors which have to be taken into account in each particular instance. I hope therefore that by confining our attentions as far as we possibly can to those essential matters, we shall be able to arrive at certain conclusions which will be useful to those who may have to design locomotive depots to meet special requirements.

I will now ask Mr. Forte to read his special report.

Mr. **Forte**, *Special Reporter*. — After reading his report, as published in the June 1925 number of the *Bulletin of the Railway Congress*, p. 2115, said (in French) : I would like to add the following. I have now finished my official duties. In order not to go outside the limits of the question itself I have had to keep the object of the question clearly before me.

I trust however that our distinguished President and my Colleagues will allow me to add a few words and to make a digression, as I wish to end my speech by a freer and more personal statement. In spite of my indifferent pronunciation, which I hope you will excuse, I am going to try to speak in English in compliment to the great nation that has welcomed us here. I shall be brief and will not develop any theory.

In the three reports submitted the various installations have been examined quickly, summarily and briefly. We have been satisfied to consider the buildings and the mechanical appliances provided for carrying out the work to be done.

It is evident that whilst this is sufficient to give a general view of the various inanimate elements of the question, it gives no indication of the physiological aspect of the life of a depot, neither does it indicate wherein lies its main functional importance.

As to-day we are assembled for the first time in the history of the Congress to examine part by part such a works, I shall not be blamed I hope if I take advantage of the occasion to consider for a moment the depot as a whole, animated as it is by the movement of locomotives coming into it for shelter, or repairs, and peopled by men industriously carrying out their duties : we could with advantage reflect, if only for an instant on the unchangeable order and harmonious forethought that made this movement and work useful and economical.

I yield to a sudden feeling of pride, which will find an echo in the hearts of the locomotive running men in the hall,

who will join with me in paying a tribute of affection to a works which imposes itself upon our attention and demands our care with as much reason, though with less prestige than the handling of powerful, fast, and yet controllable locomotives.

You will certainly agree with me in affirming that the depot owing to its separate, intimate, intense, and complex activity, and on account of the variety and difficulty of its duties, deserves to hold our attention even when compared with other works which, although larger, better equipped, and more in evidence, have simpler duties to carry out.

If we follow the work done by each section, and the locomotive to which this work is done therein; if we think of these two elements multiplied by the number of engines which pass through, and make use of, the various installations, we shall form an idea of the main function of a depot, the preparation and repair of the locomotives stationed at it.

We should now think of the many men employed in various ways in the depot, or who supervise the work done therein, and who are divided into many specialised groups, and should note their number and the way they take up their turn of duty. We should consider their moral and physical needs, their hours of rest, their conditions of employment, their professional instruction, their health and their well being. We shall then have before our eyes that other and equally complex aspect of the depot — the human one — which gives it life, strength and will.

Finally let us think of that product of the work done each day, the locomotive leaving the depot, by which however it is still controlled; let us look at the man who drives it, goes with it, feeds it, and looks after it, bound himself by the needs and restrictions already spoken of. Let us follow the cycle traced by this double entity which goes far afield, disappearing, and reappearing from time to time.

The depot then reveals itself firstly under its central aspect — that of the command — then in its entity with its strength, movement and ability to do hard work, always ready to operate heavier, faster and more intense traffic.

The above is the picture of the depot in its three functions : preparation, supervision, and instruction; and in its three elements : the installation itself, the men, and the engines.

The depots employ about one-fifth of the staff of a railway company, and cost about one-third of the operating expenditure, although they form only about three per cent of the various units into which the whole of the company may be divided.

It is consequently easy to understand that the organisation necessitates, more than in any other works of the Company, order in its methods, harmony in working, and order and subordination of powers amongst the staff.

Simple calculations of staff, wear, and consumption of stores enable the requirements of the enginemen and the locomotives to be accurately estimated, and also the number of locomotives required, the tools wanted, and the stores to be stocked. The time-tables and workings can then be arranged. The various data on organisation, output, cost and stores used can then be compiled and examined, and the results improved by better supervision and by rewards or premiums.

The different shunts, duties, places for carrying out specific duties are laid down, keeping always in mind the need for simplicity, speed and cheapness. The duties and hours of duty of all the staff are

laid down day by day : the engines and enginemen for every working are booked, and their work checked. The stores used, fresh supplies ordered, cleanliness, order and output, and also the discipline, are also supervised.

From this there is the double care : that of the organiser and that of the executive; the double task of properly dividing up the facilities available, and making the best use of them; the double supervision of the daily working of each service and of the whole.

But although I wish to be short, this is not all.

Occasionally there is a heavy increase in traffic with sudden changes in volume, which, if it exceeds a certain amount, upsets the movement of trains and also the arrangements made by the depot, as these are usually very nicely balanced as the demands are usually much the same.

The consequences are accidents, unexpected trains, heavy delays, changes in demands for engines, and unexpected failure of engines to return, all of which require unceasing diligence, prompt remedies and rapid decision.

Special knowledge, though undefinable as to its extent and method, is required to deal with breakdowns : special plant is required, and men ready to meet any demand at any time at short notice have to be taken away from the routine of the depot.

It is for this reason that there is a greater need at a depot than elsewhere for men thoroughly well trained, mentally and morally, to operate the locomotives as well as to control the depot itself.

The professional education should therefore be more thorough and more exact, the training should be longer, the selection of the staff more difficult and the discipline harder.

A spirit of tolerance and discretion should see that the pains and penalties agree with the principles of regularity and safety.

It is therefore very desirable that in addition to the installations, the other means and methods which ensure equilibrium and harmony between the different functions should be combined in a simple manner so that life and evolution are the same thing; and in which the rule is to renew, and activity becomes movement.

Each idea I have expressed is a question to be discussed, an investigation to be made, and a perfection to be realised.

I have thought it well to state my views on this occasion so that they can be considered at a future session. The works of which I speak should be appreciated as they deserve. This Cinderella of the railway should be raised to the position merited by the quiet but experienced work done, and by the influence it has on the movement of traffic. The locomotive, that perfect and harmonious organism, should be given the shelter and attention it deserves.

I have spoken of the depot with enthusiasm and affection, and hope the eminent men representing here the railways of the world will welcome my words in the same spirit.

The President. — I am sure we are all very much obliged to Mr. Forte for his eloquent address. He has lifted the locomotive shed out of the somewhat sordid position in which we usually regard it, and put it up on what one might call a poetical or ideal plane. I think we must also thank him for the compliment which he has paid us in reading his address in English.

Now I think it is desirable that we should get down to the solid facts in the

paper; and I propose therefore that we should examine certain parts of the abstract in a little more detail.

I think we might begin at the type of engine shed. There are as you know, four types : the two round house types, either with a roofed over turntable, or in the case of the segmental shed, a turntable in the open, and the two rectangular types, one with the short and numerous parallel roads and the other with long and less numerous parallel roads. There has been a very great difference of opinion as to which of those types is the most suitable in certain circumstances. I suppose it is agreed that in certain circumstances only one is indicated, but there are other circumstances in which almost any one of the four may be equally well employed; and I think it would be useful if we could lay down the factors which influence the decision in favour of one form or the other. It we could hear the advocates of the round house, and if they would tell us what they suggest are the advantages of that type, and if we could then hear the advocates of the rectangular type and hear what they consider are the advantages of that type, I think we might be able to lay down certain rules which would be a help in the future when it comes to deciding as to which is the best type of shed.

Perhaps one of the reporters will open the discussion. Will you say something, Mr. Maunsell?

Mr. Maunsell, *Reporter*. — I am afraid this is not a subject with which I am conversant. Perhaps some of the gentlemen responsible for the running sheds would be betetr able to discuss the matter.

The President. — It is, after all, a matter which intimately concerns those responsible for traffic working.

Mr. R. W. Bell, *Reporter*. — It seems to me the general opinion and practice in the United States of America favours the round house with the turntable of sufficient length to accommodate the power that is handled outside the round house. It is generally thought that the round house is preferable to the long shed, for the reason that it occupies less space, and the engine can be handled more expeditiously in and out. I think there are very few rectangular sheds in the United States.

Mr. Forte (in French). — As Mr. Bell has just told, round houses are used in the United States. In Belgium, on the contrary, rectangular sheds are preferred. I should like to know what advantages the Belgians find in these.

I wish to call your attention to what I think an important point : the tendency is towards electrification. The rectangular shed is I think more suitable for electrified lines. If we are to look ahead and take into account this indication we should decide in favour of the rectangular shed.

Mr. Pawlowski, Polish State Railways (in French). — My experience is that the rectangular shed is bad for the health of the staff as it is draughty unlike the round shed. To keep the temperature up in a round shed the building should be divided into sections, so that when one is open the others can be kept closed.

Mr. Chenu, Belgian State Railways (in French). — We think that the rectangular shed is at least as satisfactory as the round shed provided it has a traverser and a group of sidings. The movement of the engines is continuous as they come in by the traverser and go out by the sidings, and consequently do not cross. They can be grouped more easily as the entrance

and exit are separate. It seems to me that no other form of shed has so many advantages.

One supposed disadvantage is that the group of sidings is not fully utilised; but it must be remarked that part of this group and the traverser can be used to hold engines which come into the shed to wait a working, or to be turned, or for both. In such cases the engines can stand in the group of sidings, the traverser being used to move the engine quickly to the points at which any special work has to be done.

The only disadvantage of the rectangular shed as compared with the round shed is that it takes more room. From every other point of view the rectangular shed appears to me to be the best.

The rectangular shed can also be extended more easily : it is sufficient to add a second traverser and group of sidings. One of our Colleagues has said that the rectangular shed is bad for the health of the staff owing to the draughts in it. I think from this point of view, the rectangular shed with one traverser, but no group of sidings, is the best form.

The President. — Does anyone else desire to say anything on this point?

Well, Gentlemen, I think we shall have to leave this question in very general terms. It is well known that all the four types work satisfactorily in certain circumstances, and I think we shall have to leave our recommendation that the type of shed, whether circular with open or with covered turntable, or the parallel type of shed, have each their several advantages in special circumstances; and that it is not possible to recommend either one or the other type for all conditions. The type of shed decided upon must be such as suits the local conditions. I suggest the following wording :

« 1. *Type of engine shed.* — Each type of shed has its advantages and the type chosen is determined by local conditions and the views of the railway concerned. »

— This wording was accepted.

The President. — The next item which I think we might go to is equipment. I do not think we need spend any time upon construction because, as I said before, I think it is immaterial to the operating department what particular form of construction may be adopted in building the sheds; therefore I think it is not worth while discussing whether sheds should be built of concrete, or steel, or masonry or how the roofs should be constructed, and so on. I suggest that we leave that out altogether, and that we proceed to discuss special equipment.

SPECIAL EQUIPMENT. — a) *Pits.* — These are largely employed inside the shed for cleaning, inspecting, repairing and washing out locomotives, and also in some cases for carrying out inspection and minor repairs outside the shed in proximity to the entrance.

Report No. 2 mentions the use of pits for all the roads in the shed intended for accomodating locomotives, and reports Nos. 1 and 3 give the principal dimensions, and describe some typical examples as regards design, method of construction, lighting and drainage.

I do not know whether any delegates would like to discuss the question of pits. I notice that in this particular paragraph nothing is said about wheel drops, but perhaps we shall come to that later. Can we arrive at any conclusion as to whether it is necessary to have a pit for every road in the shed. Has anybody any strong views on that subject?

There does not seem to be any difference of opinion, and I suggest the wording « In certain cases all shed roads have pits » which was agreed to. We will pass from that to the next point :

b) *Recovery of oil from cotton waste used for cleaning purposes.* — The report for other countries mentions a plant of this nature which is in operation at the engine shed at Schaerbeek (Belgium).

c) *Facilities for carrying out light repairs to engines in the shed.* — The following may be mentioned :

— supply of electric current for portable drills and lamps;

— supply of compressed air for pneumatic tools;

— inspection pits or drop pits provided with means for removing a pair of wheels, report No. 1 giving a drawing and report No. 3 a description of these. They are very widely used.

Perhaps Mr. Chenu would tell us something about the plant at Schaerbeek in Belgium?

Mr. Chenu (in French). — The plant consists of a centrifugal separator. The waste can be used several times for cleaning the locomotives.

Mr. Forte (in French). — In Italy the oil and waste is not recovered by the railways, but by a private firm. The dirty waste is sent to the firm who buy it by weight and return it cleaned. At least one-third of the weight sold must be returned and is paid for by the 100 kgr. By this means we shew a saving of 20 % on the cost of new waste.

Mr. R. W. Bell. — What does the new waste cost?

Mr. Forte (in French). — The used cotton waste is collected which the firm purchase at the rate of 6 lires 50 per 100 kgr. We receive back from the firm one-third of the waste sent for cleaning, and the cleaned waste is used instead of new and has half its useful value. For example from 300 kgr. of new waste we recover the equivalent of 50 kgr. of new waste, the price of which is 200 lires the 100 kgr. at a cost of 35 lires 50. Everything included we find we have saved 64 lires 50 for each 300 kgr. of new waste of 0.21 lire the kgr. or a saving of 20 % approximately.

The President. — That answers your question, Mr. Bell, I think. I think we might pass from that by saying that the provision of engine pits for all roads, the means for recovering oil from cotton waste, and facilities for carrying out light repairs are desirable at all engine sheds. We have not discussed the last point, facilities for carrying out light repairs to engines in the shed, but I think there can be no two opinions about it that it is necessary that such light repairs should be carried out at engine sheds. If Sir Henry Fowler has anything to say about this, I am sure we should like to hear him.

Sir Henry Fowler, London Midland & Scottish Railway. — No, the point on which I was going to speak was the question of the recovery of oil and cleaning waste, because I think it is entirely wrong to say that it is desirable to have plants at every shed, which were the words you used a moment ago. It is very much better I think, to centralise the work at certain places where the dirty waste can be dealt with in bulk. I am perfectly certain that it is not advantageous in any respect to split it up into a very large number of small plants, because the most satisfactory plants that we know of for dealing with this have to deal with it in

bulk. I should like to add that in England sponge cloths are used to a very large extent in the place of waste, and the oil is extracted from them. They are washed in plants of some size, because we have found that it is not economical to deal with less than a considerable number of cloths at a time.

The President. — Then I think we might say that it is desirable that engine pits should be provided for all roads, and that facilities for carrying out light repairs should be provided at all engine sheds. Then as regards the recovery of oil from cotton waste, we might say this has been found to be economical, but it is desirable that it should be concentrated at one centre rather than carried out at every shed.

Mr. R. W. Bell. — Our experience of the recovery of oil from cotton waste after it has been used for wiping the engines has not been in line with the reports here. The experiment was carried on for several years, and we found that there was not anything in it after we had met all charges. The waste costs us 11 cents the pound.: we take that waste and wipe the upper part of the engine first and then wipe the lower part afterwards; and we find that after we get through wiping the lower part, owing to the accumulation of sand and dirt in the waste, one cannot make a very good job of the waste after it is cleaned.

The President. — This is a small point, and there are very wide differences of opinion. I think it is quite unlikely that we shall arrive at unanimity, and it seems to me that the recovery of oil from cotton waste is not really any part of the locomotive shed equipment. I suggest therefore that we leave out all reference to the recovery of oil from cotton waste. I do not know whether that is your wish.

Mr. R. W. Bell. — I might add that after we are through with the cleaning we fire up engines with the waste. That is about the only use we can find for it.

The President. — Is it your view that we should include something about the recovery of oil?

Mr. R. W. Bell. — This question has something to do with the upkeep of the engine. The value of the cotton waste which is used for wiping the engines amounts to several hundred thousand dollars a year with us, and I should like to get more information about it. We have concluded that we could not get it clean and make a satisfactory job, but if there are any members here who are doing this successfully, we should like to find it out, because we want to save this money.

Mr. Bals, Roumanian State Railways (in French). — I hear that some Administrations use sponge cloths for cleaning purposes. I should like to know if from the point of view of the recovery of material, sponge cloths give better results.

Mr. Maunsell. — Sponge cloths are largely used in England, and satisfactory results are obtained so long as the quality of the sponge cloth used is good. If an inferior type of sponge cloth is used, then the cost exceeds that of waste, but the use of good sponge cloths is more economical.

Mr. R. W. Bell. — Is that a patent sort of cloth?

Sir Henry Fowler. — Perhaps it would be interesting if we produced some this afternoon. (*A number were shown later.*)

Mr. R. W. Bell. — The cost of hand-

ling engines is a live subject with us. We are limited to a certain amount for the handling of every locomotive, and if we go beyond that we must explain. We are constantly trying to keep our expenses down in that direction. One of the items which enters into the cost of handling the locomotives at the terminals is cotton waste, and if we can get any information on the matter of reducing the cost of the waste, then we shall have accomplished something.

The President. — I am afraid it will be a little difficult to get such information as Mr. Bell desires in open meeting, but probably if he would communicate with Sir Henry Fowler or with Mr. Maunsell, who have had trials of apparatus for the recovery of oil from cotton waste or sponge cloths going on for a number of years, he would get the information that he desires. I think, possibly, to arrive at a conclusion on this particular point, we might say that in certain installations it has been found economical to put down a plant for the recovery of oil from cotton waste; and leave it at that. There seems to be some little difference of opinion as to whether the wording is correct, whether it is correct to say « recovery of oil »; that is to say, whether the oil recovered is usable, or only the cotton waste.

Mr. Maunsell. — The oil which is recovered is made use of very largely, I believe, in your department; and my recollection, speaking from memory, is that the value of it is 5 d. or 6 d. a gallon.

The President. — Then I think the wording is correct as we have it.

Mr. Maunsell. — The recovered waste I think is also used.

The President. — Yes, that is understood, I think, that the recovered waste is also usable. I propose the following wording which was accepted :

« In certain circumstances it has been found advantageous to put down plant for the recovery of oil and waste from dirty waste. »

The President. — We will now consider :

d) *Arrangements for washing out and refilling boilers.* — The British and American reports mention a general preference for hot washing out and state that this is widely used; the report for the other countries, while recognising the undeniable and well known advantages of this system, has to confess that the practice of washing out with cold water is still very generally adopted.

In addition to the ordinary water supply for washing out, use is made of injectors supplied with steam from a central boiler or from another locomotive on an adjacent road, or of motor driven pumps, and in the case of some of the larger sheds, of special plant for providing hot water.

Report No. 3 describes, under this heading, the type of plant most widely used in America, and report No. 2 mentions a special installation for recovering the heat contained in the water run off from boilers similar to that adopted on the Italian State Railways and on the Belgian Railways.

The same installations which provide hot water for washing out, provide water for refilling boilers; but as regards the temperature of the water, report No. 2 points out that although washing out with hot water, followed by refilling with hot water assists in reducing the time during which a locomotive is kept out of service, too high a temperature for the washing out water and subsequent refilling with water and steam under pressure gives rise to difficulties and dangers in handling the apparatus and is detrimental to the boiler plates.

The temperature obtained and adopted with the above mentioned installations for recovering the heat gives a temperature of about 131° F. for washing out, and 185° F. for refilling the boilers.

These plants prove satisfactory if their simplicity and consequently moderate cost of erection and upkeep compares with the amount of heat regained, or in other words, if the amount of coal saved shews an overall economy. These requirements have been found to be satisfied in some cases, provided that the plant is efficiently handled and that a sufficient number of engines are being simultaneously emptied and washed out each day.

So far as I know, this question of washing out and the use of hot water for washing out and refilling has been developed to a large extent in America and elsewhere; and I saw at Selkirk one of the finest installations that I have seen anywhere, and probably that exists anywhere. Probably Mr. Bell will tell us how that works, and what are the disadvantages of using hot water. The advantages are patent to everyone, but we should like to know what are the disadvantages of using hot water for washing out and refilling. Would you give us some information about it, Mr. Bell?

Mr. R. W. Bell. — About all there is to speak of is the matter of the temperature of the water. In the washing out of the boiler and refilling the boiler with hot water after it is washed out, in the handling of the hose, the man who washes out objects very seriously to handling water of a temperature of over 190 or 195° Fahr. It is pretty hard on his hands. We have found that we get very excellent results by having the water at that temperature. As for the matter of damaging the sheets by introducing hot water against them, that will depend upon the temperature of the sheets.

The President. — Your remarks apply also to refilling with hot water, I take it, Mr. Bell?

Mr. R. W. Bell. — Yes, refilling and washing too. As to the question of washing with hot water versus cold water, I might add that we have some of our terminals where we despatch 125 engines in 24 hours; they are all very large engines; they have a tractive effort averaging 65 000 lb., and we could not possibly handle that number of engines if we did not have the hot water washing system. It could not be done with cold water.

Mr. Pawlowski (in French). — Hot water washing out obviously shortens the time taken, which is important at large sheds where there are many engines. Further, the plates are not cooled off, and the boilers last longer. In Poland the work is centralised, the steam being sent into one tank and the hot water into another; the boiler then empty is washed out at once.

Mr. Forte, *Special Reporter* (in French). — My report states : « Cold water washing out is still widely used. » The different replies I received made this clear. In Italy both hot and cold water washing out is done. When the engine is required quickly and there is not time to cool down the boiler completely, it has to be washed out with hot water. In Italy as a rule the driver has his own engine. When the driver is off duty the engine is in shed; according to the time available the engine is washed out with either hot or cold water. The temperature of the washing out water should be the same as that of the boiler. The easier way to get hot water is to heat up the water in the tender by the steam from the engine itself. We can get thereby water at 95 to 104° F. which

is sufficient to avoid damaging the plates.

The required pressure can be obtained with motor pumps, but in this way the water loses some of its heat.

Central hot water washing out and refilling plants have been installed at the modern depots at Turin, Milan-Lambrate, Nestre, and Rome S. L. These plants draw off the water and steam from boilers being emptied and as a result washing out water at 122° F. and refilling at 176° F. is always available. These plants have been found to be economical and desirable at the larger depots.

Mr. Poncet, Eastern Railway, France (in French). — The French Eastern Railway has collected complete figures of the temperatures in boilers during cooling down. It has been found that when the pressure falls to zero, the temperature at the top of the water is double that at the bottom. At the upper part the temperature is 212° F., at the lower part 131° F., or a difference of 81° F. After standing 20 hours differences of from 54 to 72° F. are found.

We have therefore come to the conclusion that harm was done if water at a temperature of 86 to 95° F. was used. In France the regulations require the engine drivers to be given four times each month a long rest of at least 38 hours. As each driver has his own engine there is sufficient time to wash out the boilers.

We have decided to cool down the boilers and wash them out with cold water. When an engine comes into the depot it is allowed to stand a certain time and not less than 10 hours, after which, through a cock provided at the front end of the boiler, cold water is pumped into the boiler at the rate of 260 British gallons an hour. Temperatures have been taken and show that the cooling down took place at a regular rate, and the tube plates were not damaged.

At the end of 5 or 6, or sometimes even 10 hours, depending upon the time the engine was standing, the boiler becomes cold and at the temperature of the surrounding atmosphere, that is, 50 to 59° F. We then wash out with cold water under pressure from the reservoirs or from pumps. This method has given good results and we no longer have leaky tube plates.

The cold water goes in towards the front end of the boiler and well away from the most vulnerable part, the firebox tube plate. As small quantities are introduced at a time the water in the boiler is cooled down gradually, and the tube plates are not subjected to sudden changes of temperature. Since we introduced this method of cooling down the tube plates have given little trouble.

The President. — Gentlemen, it is quite clear that there are advocates of cold water as well as advocates for hot water. I do not know whether you would be prepared to agree to a note of this sort : « The use of hot water for washing out and refilling is essential when engines have to be retained at the shed for the shortest possible time. »

Sir Henry Fowler. — I wish to add one other thing. I only want to remark that there is a great advantage in many cases of peculiarly bad water in letting the water go while it is very hot, because it prevents certain of the salts settling down as scale; and with certain waters that is a very great advantage.

The President. — I am not quite sure whether I understand. It is possible. I take it, to wash out the boilers with hot water even if you let out the bad water which is in them.

Sir Henry Fowler. — It is very undesirable to let water out at too high a pressure — that is to say, at too high a temperature. That is so from a locomotive standpoint as well as from a water standpoint.

Mr. R. W. Bell. — Before letting the water out of the boiler, the pressure is reduced. We approach all of these questions from a monetary standpoint. One gentleman here mentioned the matter of letting the boiler washers-out rest between their periods of washing out an engine. We do not let them rest; we demand an hour's work for an hour's pay. It costs us $250 a month for a boiler washer-out and his helper, and that is also considered in the cost of handling our locomotive at the terminal. If we have six boiler washers, and we have six helpers, then the question arises. « Why can you not reduce one boiler washer and one helper, and save $250 a month? » That is one of the reasons, too, why we wash out with hot water.

The President. — Excuse me, Mr. Bell, but I think the point put was that in some cases the engine crew follows the engine, and that when the driver and fireman are away having their rest, there is no disadvantage in allowing the water to cool down, because it cools down in any case in the 36 hours.

Sir Henry Fowler. — Except that it may drop some of its scale forming salts, which it otherwise would not do.

Mr. R. W. Bell. — In the United States, on the Illinois Central System, which extends from Chicago to the Mississippi Valley, and where we have 1936 locomotives, we are one of two or possibly three systems which have engines regularly crewed. We never pool our engines. The engineer and the fireman follow the engine as long as they are able to follow it, through the month and through the year and when the engine goes into the shop for heavy repairs we provide them with another engine. Even under those conditions, we have found it advantageous to wash with hot water, because from the time when the engine arrives on the cinder pit coming in until the time when it is ready again will be a matter of eight or nine hours, and their rest is up. They will have had their rest, and they are prepared to go again, so that we must have the engine ready.

The President. — Gentlemen, will you agree to a modification in this sense : « The use of hot water for washing out and refilling boilers is desirable when engines have to be retained at the sheds for the shortest possible time. » Does anybody object to that?

Mr. Pawlowski (in French). — This wording mentions hot water washing out only and narrows the question.

I should like to remark, and it has not yet been mentioned during the discussion, that washing out with hot water removes from the boilers salts already there. The same result is not got when cold water is used. When the water is in ebullition, the salts are brought to the surface and can be removed readily.

One of our engineers, Mr. Arcisz of Wilno, Poland, who has worked in Russia for more than forty years has invented apparatus for removing the salts from the water whilst the engine is running.

The President. — I do not think we are making much progress. I propose to put this to the meeting, and if anybody has any definite proposal to make which is different I hope he will make it, otherwise I will put this to you and

see whether it will go through or not. The wording suggested is : « The use of hot water for washing out and refilling boilers is desirable when engines have to be retained in the shed for the shortest possible time. » If anybody has anything which they would like to substitute for that, perhaps they will move it.

Mr. Maunsell. — I should like to propose that what you suggest terminates at the word « desirable ».

The President. — I do not think Mr. Maunsell's suggestion will be acceptable, because there are certainly many here who consider the use of hot water to be undesirable. If he does not object, therefore, I propose to put to the meeting the motion as I read it — which was then carried.

The next paragraph is :

e) *Lighting up locomotives.* — The most generally used method is to employ wood, which is lighted in the firebox with discarded pieces of oily waste. Some administrations use live coals from special fires which are used for drying the sand, warming water, or other purposes.

Another method consists in spreading a layer of coal in the box, spraying this with oil by means of a jet of air and steam mixed and then igniting this. Other railways on the other hand, as is shewn in a table attached to report No. 1, use special fire lighters made of wood soaked in inflammable material, or else an oil flame projected on to the coal by means of compressed air. The rate at which steam is raised in the early stages may also be accelerated by using a blower supplied with steam from another source, but report No. 1 does not recommend this method.

It seems to me that this is hardly suitable for discussion. There are many ways of lighting up locomotives, and they do not seem to me to depend upon the design of the shed. Unless anyone particularly wants to address the meeting on the subject of lighting up locomotives, I propose to leave that question and to proceed to the next. (*Assent.*)

The next item is :

f) *Special provision for removing smoke.* — Special arrangements are generally recognised as being necessary.

However, mechanical installations for this purpose are very rare; the American report mentions several types with underground or overhead conduits leading to a central chamber from which the smoke and air are discharged into a chimney, either directly or after having been washed by contact with water. Such installations are only used where local regulations render it necessary.

The provision of a tall central chimney and a system of closed hoods or flues fitting on the chimneys of the engines are adopted by some European administrations. As it is recognised that these are effective in reducing the time necessary to raise steam and also for heating the shed, they are still in favour on certain railways; however, the majority are not convinced of their practical utility or convenience for two reasons : firstly because engines cannot always be placed at one definite position during the whole of the time they are in the shed, and secondly because the cost of erecting and maintaining such devices is considerable.

Therefore, the type which is most preferred, which is the only one mentioned in the British report, is that which consists of fixed hoods with separate chimneys constructed of concrete, asbestos, « eternite » or wood, with a rectangular opening, having its greatest length along the line of the track and — in the case of long parallel roads in rectangular sheds — the tops of the troughs are slop-

ed upwards towards uptakes which are provided at intervals of about 20 feet.

There are, however, a number of administrations who, instead of employing arrangements of this kind, content themselves with providing sufficient natural ventilation.

It is of course desirable that the smoke should be removed as quickly as possible from the engine shed, but the means for doing so are pretty well known. The only special means described in the paper is the provision of a tall central chimney connected with the hoods in the shed; but the paper goes on to say that this means is costly and not altogether successful, so in that case it seems to me that unless there are advocates of that special type of ventilation, this is a question which might also be left over without discussion.

— This was agreed to.

The President. — We will pass on to the next subject :

g) *Lighting and heating of sheds.* — The most generally adopted form of artificial illumination is electric lighting, preferably with incandescent lamps, which is rendered still more convenient by the use of portable lamps for inspecting and repairing locomotives. However, there are a number of examples where gas lighting is used; report No. 1 gives a photograph of an installation of this kind.

For heating sheds, report No. 2 states that during very cold weather, the administrations concerned still use, as a rule, stoves or braziers, stating that the latter have very little effect on the general temperature in the shed, and serve rather as a means of warming one's hands, using a large amount of fuel and causing damage to the building.

However, in very cold climates in the more important sheds, central heating apparatus using steam or hot water are employed. This latter system is the most satisfactory, but it entails considerable first cost; report No. 3 gives details of this, and states the advantages gained.

This question is important. It is unnecessary I think to deal with the relative advantages of gas and electric light. We should however give some consideration to the question of heating. In severe climates, such as that of North America, I know that very complete heating installations are to be found at depots, but so far as I am aware they are not found in Great Britain. Possibly better facilities and more attention to the comfort of the depot staff will have to be provided in future than was the case in the past.

If anyone wishes to address the meeting we shall be pleased to hear him.

After an interval : There is no need for us to make any suggestion on this question. Most probably each Company will do what it thinks necessary with regard to the heating and lighting.

Now we come to :

b) *Shed Workshop.*

Report No. 2 deals at length with workshops at locomotive sheds, considered as a separate feature; it discusses the work which is required to be undertaken and gives information as regards the lay-out, principal dimensions and equipment, dealing especially with lifting tackle, this being also dealt with in the other two reports. It expresses an opinion on the type and capacity of the machine tools (report No. 3 gives two typical examples of the machine tool equipment) and calls attention to certain equipment which has been found to be of utility. It contents itself with making the following statements which we will reproduce *in extenso*, because although only applying to other than English

speaking countries, they may be of utility and serve as a basis for a useful discussion.

1. — Generally speaking, the running shed must carry out all repairs to its locomotives, other than heavy repairs, and maintain them in good order. In order to do this, not only must small repairs and partial overhauls be done, but a carefully thought out programme should be laid down, for each engine, of the medium repairs to be carried out. In each case it has to be decided if the running shed should carry out special repairs of considerable extent, bearing in mind the equipment of the shed and extent to which it is available and the speed and ease with which the repairs can be carried out.

That is a general statement. If you agree with the conclusion which I have just read out, we can pass it and go on to the next; or if anyone wishes to discuss the question of repairs from the point of view of differentiation between heavy repairs, light repairs and moderately heavy repairs, we shall be glad to hear them, although I doubt whether we shall be able to arrive at any very satisfactory conclusion on the classification of repairs.

Mr. Chenu (in French).— In Belgium the method mentioned in the report has been given up and the repairs of locomotives are centralised according to type at the workshops attached to the sheds. Out of a total of sixty sheds, there are now only about thirty where light repairs are carried out.

It may happen that a depot with a repair shop does send its engines to another depot for repairs in cases where types of engines are concerned which it does not usually repair.

We find this method very profitable; the output of the shops is increased, a saving in standing charges is effected, and as the stores are always well stocked, spare parts are quickly obtained.

Mr. Renevey, Alsace and Lorraine Railway, France (in French). — I am not of the same opinion as Mr. Chenu. After the armistice, we found on the Alsace-Lorraine Railway the organisation which he has just praised. It is true that, owing to the war, the number of engines to be repaired was great, but this was not the principal factor which caused us to see that the methods in use did not give good results.

The principal reason was that carrying out repairs elsewhere than at the depot divided the responsibility between the depot superintendent and the works manager. In the difficult period following the war, it was found that each depot ceased to interest itself in the proper maintenance of the locomotive and in the attention the drivers should give their engines to keep them up properly. The reason was that the engines would be sent away to be repaired.

On the other hand, the works wished to put the engines into thoroughly good order so that the shed superintendent should not be able to criticise them, and repairs were carried out to an extent that was often unnecessary. At one time there was a considerable percentage of the engines stopped.

When the system was reorganised this method was given up in favour of that of the other French systems, that is to say, the shed superintendent, is as far as possible responsible for the upkeep of his stock. This method has given good results.

I should like to add that the German method in use on the Alsace-Lorraine Railway up to the war had the disadvantage that many engines had to be sent

from the sheds to the works which had to do the repairs at a considerable annual cost and with an increase in the number of engines waiting for repairs.

Mr. Pawlowski (in French). — In Poland our experience has been that of Mr. Renevey in Alsace-Lorraine. In those countries where distances are great, to send locomotives a long way to be repaired causes an appreciable loss of time, and an expenditure which should be reduced to the minimum.

Mr. Chenu (in French). — It has been pointed out that the system under which shed repairs are dealt with at central points has the disadvantage that it divides the responsibility for the condition of the engine between two separate offices. It is true; but this is always the case so far as heavy repairs are concerned.

It has been said also that the repairs done may be excessive or insufficient. To get over this real difficulty care must be taken to lay down as carefully as possible the repairs to be done.

It has been remarked that by centralising these repairs engines have to be sent long distances light. This depends upon the number of lines belonging to the railway. In Belgium these distances are short.

I wish to stress once again the very great advantages of the method I support. Where there are as many shops for light repairs as there are depots, these shops cannot be properly equipped with tools, that is, machine tools of high capacity. It is clear that such tools are not to be had at the little shops. At the shops especially laid out for this work there is also a skilled staff able to give a good output.

Mr. Lacoin, Paris-Orleans Railway, France (in French). — May we be told what is the percentage of engines stopped for repairs on the Belgian system?

Mr. Chenu (in French). — The percentages vary with the work done by the locomotive. Passenger train locomotives on long runs do 50 000 miles between two medium repairs, and the repairs take on an average 25 days.

Mr. Renevey (in French). — Mr. Chenu has very clearly brought forward the advantages of specialised workshops. I should like, however, to say that we obtain the same benefit but in a different way. The workshops repair detail parts, of which we have formed stocks which can be supplied to the depots wanting them quickly.

The time the engine is stopped is thereby reduced. The number of engines stopped averages from 11 1/2 to 12 1/2 % of the stock at any moment. By « stopped » I mean any engine which cannot go into traffic within 24 hours of its coming into shed.

Mr. Forte, *Special Reporter* (in French). — I support Mr. Renevey's arguments just put forward.

In Italy we deal with the question as is done in France. I consider it advisable to separate heavy from medium repairs. At the depots there is the necessary equipment for carrying out medium repairs. Heavy repairs should be kept out as they cannot be done at the depots. For medium repairs I do not think main shops to be required. I still hold to my conclusions and ask the section to fall into line.

The President. — Just to test the feeling of the meeting, I would suggest that our conclusions be confined to the first four lines of paragraph 1, and that the remainder of the paragraph be left

out. I should like to know whether we are in general agreement that the conclusion should read as follows : « Generally speaking, the repair shed must carry out all repairs to its locomotives other than heavy repairs, and maintain them in good order, » and stop at that.

Mr. Chenu (in French). — I am unable to agree. Would it not be better to say : « Generally speaking, running sheds carry out all repairs to their locomotives other than heavy repairs, and maintain them in good order. »

The President. — I propose that the wording suggested by Mr. Chenu be adopted, which was agreed to.

The President. — I should like to say, Gentlemen, that it has been suggested, and one or two have intimated that it would be satisfactory to them, that we should not sit this afternoon, but continue to one o'clock, and if necessary, again tomorrow at 9.30 a. m.

Before we continue with these items on shed workshops, I would like to give Mr. Maunsell, one of the reporters, an opportunity of speaking on coaling appliances. He will not be able to be here to-morrow, and with your permission, I will ask him to give us his remarks now.

Mr. Maunsell. — Mr. President and Gentlemen. The high labour costs in this country have made it desirable — perhaps I might say essential — to introduce some methods of mechanical coaling in our larger locomotive depots. In Great Britain, and I know it is so in America from the report of the American representative, much the same kinds of plant are in use. There are two types employed in this country, the type which uses a belt conveyor, by means of which the coal is distributed either into tubs or directly on to the tender, and there is the type in which the wagon of coal is elevated and discharged into bins, from whence it is fed to the tender by means of gravity. Both types of plant appear, as far as saving in labour costs is concerned, to work satisfactorily, and both types of plant appear to deal satisfactorily with some classes of coal which we have to use in this country. On the Southern Line, however, a very large quantity of South Wales coal is used, which coal, as most of the representatives here will know is of a very soft and friable nature, and we have found by experience, particularly in plants in which this quality of coal is elevated in wagons and discharged into hoppers, that by the time it arrives on the tender of the engine it has been very much damaged and very much broken up. The percentage of coal dust which is delivered on to the tender is very large, and a great deal of that is lost in two ways : it is lost by being drawn directly through the tubes into the smoke box of the engine in the form of unburnt fuel, and it is also lost — and the loss is serious — by being blown off the tender before it ever reaches the firebox at all. I have recently carried out some experiments with South Wales coal, used in two ways: one, put on the tender in the ordinary way, that is to say, by manual labour direct from wagons, and the other by means of a mechanical coaling plant. A three day test was made, and subsequently that test was repeated, and another three day test was made, and test No. 2 corroborated test No. 1. The result was that in using coal which has passed through the mechanical coaling plant, we experienced a loss of 9 to 10 %, which I need scarcely point out is a very serious loss.

The President. — Did that apply to the conveyor or to the tippler?

Mr. Maunsell. — That applied to the tippler plant. Seeing that it is practically speaking a necessity, in view of the high labour charges to which I have referred, to get coal on to our tenders by some mechanical means, I am very anxious to know whether some of the delegates here, either from the Continent of Europe or from America, have experienced any trouble in using the softer qualities of coal which they may burn, when they coal engines by means of mechanical power.

The President. — Does anyone desire to address the meeting on the subject of coaling plant? Mr. Maunsell has asked for certain information which no doubt delegates here possess, and which we shall be very glad to hear if they will kindly let us have it.

Mr. R. W. Bell. — In answer to Mr. Maunsell's question, we handle coal by hand and by mechanical plant, and we find that where we handle our coal through the mechanical plant it is broken up a great deal, and we lose a great deal in the consumption of coal by this coal being broken up. However, at some of our smaller stations we still retain the system of handling coal from the car to the locomotive tender by hand; we shovel it up : but at the larger stations we cannot take time to do that. Our cost of handling coal averages 6 cents per ton, and we put out cost of handling the coal against the loss in consumption. Six cents per ton is the average cost laid down on the tender, that is the labour cost of handling.

May I add that we issue at the end of every month a statement showing the labour costs and the material costs for handling the coal all over the system, comprising about 6 200 miles, and if any of the members would like to have that report, I would be very glad to send it to them.

The President. — Thank you very much. I am sure many of us would like to have that. I do not think we can go into the various types of conveyors and coaling plants. I would like to suggest that the note be somewhat as follows : « Mechanical coaling is increasing. There is a loss owing to breakage of coal, but at the larger sheds this is counterbalanced by the saving in the cost of labour. » (The suggested wording was translated into French.)

I think we have it slightly out of order. The breakage of coal, I understand from Mr. Maunsell, applies only where soft coal is used. Where the harder coals are used, such disadvantage is not felt. The wording proposed, therefore, is as follows : « Mechanical coaling is increasing at the larger sheds. Where soft coal is in use, there is a loss owing to breakage, but this loss is counterbalanced by a saving in the cost of labour. » Is that agreed to? If no one raises any objection to those words, we will pass from mechanical coaling plant and we will go back to item 2 of *b*, « *Shed Workshop* ». That reads :

> The lifting and erecting shop should be able to contain 8 to 12 % of the engines stationed at the running shed, and sufficient pits should be provided for this number; some would be used for inspection or changing wheels and axles. The shop should be fitted with the necessary appliances for lifting the engines quickly and safely, such as screw jacks, stools and cranes of sufficient capacity. A rectangular shop with short parallel roads is the most suitable for this purpose.

I do not know whether we are in agreement as to the percentage mentioned.

Mr. Weiss, Swiss Federal Railways (in French). — It is difficult to ascertain the percentage, seeing that different methods are used in different countries. It would be better not to give the figures. In Switzerland there is not a single depot with cranes for lifting engines. At the large depots there are always pits with hydraulic wheel drops.

The President. — I suggest we stop at the words : « and for replacing wheels and axles. » The rest of the paragraph would be left out. The text would then be worded :

« The repair shop should be able to contain a reasonable proportion of the engines stationed at the running shed, and sufficient pits should be provided for this number; some would be used for inspection or changing wheels and axles. »

— The text was agreed to.

The President. — We will now pass on to paragraph 3.

It is possible to arrive at a ratio between the number of locomotives at a running shed and of the machine tools with which the shop should be fitted.

I think we might leave that out; and I think the same applies to Article 4 :

Of special machine tools, wheel lathes and vertical boring mills for dealing with piston rings are most useful at a running shed.

— Then we come to No. 5 :

Compressed air and oxy-acetylene welding are of great use at a locomotive shed; on the other hand, plant for repairing tubes and springs is not to be recommended.

Mr. Forte, *Special Reporter* (in French). — I promised my Colleagues the following notes on oxy-acetylene welding :

Note on the autogenous welding of cop-

Locomotive.	*Repairs done to the tube plates.*	*Date work carried out.*	*Locomotive depot.*	*Date of last inspection.*	*Cost of repairs.*		*Saving.*
					Welding.	*Mechanical methods.*	
290.104	Welding of 24 cracks in the drilled part of the tube plate. Filling up 6 holes in the same plate.	July 1924	Pisa.	24 April 1925	600 lires.	12 390 lires (1)	5 590 lires (3)
730.162	Welding of 24 cracks in the drilled part of the tube plate, in the flanges, and between the rivet holes.	October 1924	Milan (Simplon).	16 April 1925	860 —	16 510 lires (1)	7 392 lires (3)
685.038	Welding of 9 cracks in the drilled part of the tube plate between the flue tubes of the superheater.	February 1925	Rome (St. Laurente.	26 May 1925	535 —	17 935 lires (1)	8 430 lires (3)
940.044	Welding of 6 cracks in the drilled part of the tube plate.	October 1924	Tivoli.	5 May 1925	350 —	2 005 lires (2)	1 655 lires

(1) Plate changed. — (2) Patch 10 mm. (3/8 inch) thick. — (3) The mean life of the tube plate is taken as 4 years, which is increased to 6 by welding.
The figures show the total saving made during this time.

per firebox plates of locomotives, sent to the London Session of the International Railway Congress of 1925 by the Italian State Railways.

It should be remembered that as long ago as 1913 experiments were started under the control of the late Signor Grieco, an engineer of the shops at Naples, with a view to securing patches on worn or damaged firebox plates and especially on the back plates. As an experiment, tests were also made to weld up cracks in the side flanges of the tube plates.

Satisfactory results were obtained, but owing to the death of the experimenter, the use of this method was not as widely extended as might have been expected in the conditions rising out of the war. The subsequent repairs done in this way were not done as experiments but were temporary expedients due to the shortage of copper experienced at that time.

At the end of the war, the question was again taken up and gone into with the thoroughness possible thanks to sound technical methods known also elsewhere, and to the greater ease with which the necessary materials were obtainable. The pre-war tests had been made with alloys of copper not at all suitable for the purpose, to which must be ascribed the fact that the use of welding did not become as widespread as was to be expected.

After the war, as a result of a very careful examination of the question and of investigations carried out to overcome the various difficulties which prevented the practical use of autogenous welding, new experiments were started in this direction and then the first practical tests were made in our shops at Florence (Porta al Prato).

Without going into details, in view of the encouraging results of these first operations, the new method was applied to many repairs to damaged tube plates of locomotive in the locomotive depots, in all cases without taking out the boiler. The attached table gives details of some cases.

The principal shops also carried out repairs of varying importance, which could have been done at the depots, and will be in future as opportunity occurs.

Very careful inspections carried out regularly by the engineers responsible proved that the first plates repaired by welding did not show any signs of incipient or serious damage where repaired after 10 months service.

The tests have been extended both in the principal shops and in the depots, so that there are now forty-five locomotives repaired by welding in service or about to be returned to traffic.

In view of the results obtained, the use of this method may be expected to become general and become part of the ordinary practice. It is easy to deduct that one of the results will be a longer life of the firebox plates, a reduction in the costs of repairs, an appreciable reduction in the number of locomotives stopped, and consequently, a better return from the capital represented by the locomotives.

I think therefore an autogenous welding plant can give great useful service in a depot.

The President. — I propose we leave out the last phrase of paragraph 5 : « On the other hand, plant for repairing tubes and springs is not to be recommended »; which was agreed to.

We will now deal with section *c* : *The Stores.*

« Proper provision should be made at each locomotive shed of the following materials :

a) Tools or equipment for temporary issue or as a reserve stock;

b) Spare parts or material;

c) Oils;

d) Various consumable stores for use on locomotives and by the staff. »

— The proposed wording was accepted.

The President. — I suggest the discussion be continued at the next meeting.

— This was agreed to, and the meeting adjourned at 1.10 p. m.

Meeting held on 1 July 1925 (morning).

Mr. TRENCH, IN THE CHAIR.

— The meeting opened at 9.30 a. m.

The President. — Gentlemen, it has been suggested that it would be desirable, before we proceed with the further consideration of the paper, to read the summary we arrived at yesterday. It is not suggested that it is to be read with a view of inviting the re-opening of the discussion on each of the different points; but if there is any word which does not meet with the views expressed yesterday, and does not convey the sense of the resolution as passed, we shall be quite prepared to amend that word. Beyond that, we do not propose to discuss the matter further. I will ask the Secretary to read the summary as passed yesterday.

Mr. Bulleid, *Secretary.* — « 1. *Type of engine shed.* — Each type of engine shed has its advantages, and the type chosen is determined by local conditions and the views of the railway concerned.

« 2. *Pits.* — In some sheds all roads are provided with pits.

« 3. *Recovery of oil and waste from waste used for cleaning purposes.* — In certain circumstances it has been found advantageous to put down plant for the recovery of oil and waste from dirty waste.

« 4. *Arrangements for washing out and refilling boilers.* — The use of hot water for washing out and refilling boilers can be recommended when engines have to be kept at the shed for the shortest possible time.

« 5. *Shed workshop.* — Generally speaking, running sheds carry out all repairs to their locomotives, other than heavy repairs, and maintain them in good order.

« The repair shop should be able to contain a reasonable proportion of the engines stationed at the running shed, and sufficient pits should be provided for this number; some would be used for inspection or changing wheels and axles.

« Compressed air and oxy-acetylene welding are of great use at a locomotive shed. »

Sir Henry Fowler. — May I raise one point here? I had to attend the Permanent Commission yesterday, although I was very anxious to take part in this discussion. I think that this is a little too general; and if I may be allowed to do so, I would suggest that we should add. « The extent of the repairs to be carried out depends upon the local conditions. » That would cover everything, and at the same time would not alter the general meaning, because what is desir-

able in a country which is very thickly populated is perhaps not desirable in a country which is sparsely populated, and in which there are very long lengths of line without any shed at all.

Mr. Renevey (in French). — It would be better to say « upon local arrangements ».

The President. — I think Sir Henry Fowler's view is that we have made a rather general statement, and that it might be taken that every shed must be provided with the plant and machinery which we have detailed in this article, whereas that does not really apply. At some sheds this plant is available; at other sheds it is not, and that depends upon local conditions. I see no objection to the proposed addition, if it is your pleasure that it should be made.

Mr. Bulleid. — Read paragraph 5 amended as suggested by Sir Henry Fowler.

The President. — Mr. Weiss suggests that if we put in the interpolation suggested by Sir Henry Fowler, the following paragraph will be inconsistent. The following paragraph is : « The repair shop should be able to contain a reasonable proportion of the engines stationed at the running shed, and sufficient pits should be provided for this number. Some would be used for inspection or changing wheels and axles. » I do not see anything inconsistent in that; it seems to me a statement of fact which is correct.

Mr. Renevey (in French). — At many depots electric welding is also used and should, I think, be mentioned.

Mr. Forte (in French). — There is an appreciable difference between oxy-acetylene and electric welding. Without questioning the importance of electric welding in locomotive depots, I should like to remark that it has not the same utility as oxy-acetylene for welding copper boiler plates. It also has the disadvantage that attention must be paid to the different current available, sometimes alternating, other times continuous. According to the current, special appliances are required.

Possibly at some future date electric welding may be able to meet all requirements and especially for renewing parts, but at the present time oxy-acetylene welding is the most useful.

Mr. Renevey (in French). — I agree that electric welding is not suitable for repairing copper firebox plates. At depots there are not only boilers with copper plates, but also many steel fireboxes with which many French engines and particularly those of American origin are fitted.

Welding with the flame in these steel boxes is very difficult as the plates have to be made very hot, and on cooling abnormal stresses result. In these steel boxes electric welding gives good results when patching as it is only necessary to heat the plates locally. It is for this reason that I think we should not omit from our summary any mention of this method of welding, as its use can be justified especially at the important depots.

The President. — I propose to say : « Compressed air and oxy-acetylene and electric welding are of great use at a locomotive shed. »

— This was agreed to.

The President. — Paragraph 5 relating to the repair shop should be worded as follows : « Generally speaking, running sheds carry out all repairs to their

locomotives other than heavy repairs, and maintain them in good order. The extent of the repairs to be carried out at the shed depends upon local conditions.

« The repair shop should be able to contain a reasonable proportion of the engines stationed at the running shed, and sufficient pits should be provided for this number; some would be used for inspection or changing wheels and axles.

« Compressed air and oxy-acetylene and electric welding are of great use at a locomotive shed. »

— This was agreed to.

The President. — Summary 6. — *The stores* — should be worded as follows : « 6. *Stores.* — Proper provision should be made at each locomotive shed of the following materials :

« *a*) Tools or equipment for temporary issue or as a reserve stock;
« *b*) Spare parts or material;
« *c*) Oils;
« *d*) Various consumable stores for use on locomotives and by the staff. »

— And this was agreed to.

The President. — Paragraph 7 dealing with coal stacks and coal handling could be worded as follows : « 7. *Coal stage.* — The use of mechanical coaling is increasing at the larger sheds. Where soft coal is used there is a loss owing to breakage, but this is counterbalanced by the saving in cost of labour. »

— And this wording was accepted.

The President. — The following section *e* deals with the buildings and accessory equipment, and dealing with 1 — *Distribution of sand* — the summary suggested is worded as follows :

1. — *Provision of sand.* — Simple methods of artificially drying sand are used, and report No. 1 gives drawings to two types of furnaces in use for this purpose, while report No. 3 describes other drying apparatus, either with a furnace or by steam pipes. There are also examples of mechanical means or compressed air devices for handling the sand before or after drying, and such methods are coming into use, especially at the larger sheds.

As there is no recommendation or conclusion made, I suggest we leave this out.

— The meeting agreed to do so.

The President. — No. 2 deals with the removal, disposal of ashes, etc., and the suggested wording of the summary is as follows :

2. — *Removal and disposal of ashes,* etc. — For the smokebox char, report No. 1 gives a method of removing this by means of a steam ejector. Report No. 3 states that in America locomotives are now constructed in such a way that they automatically discharge smokebox ashes through the chimney by means of the draught produced by the exhaust.

For removing ashes from the ashpan, as a rule ashpits are used, which are provided in some cases with jets of water for slacking the ashes; in most cases mechanical means are used for removing the ashes and loading these into wagons. Reports Nos. 2 and 3 mention or describe some of these methods, and report No. 1 gives three other typical examples of this kind.

The recovery of coke from the ashes, done either manually, mechanically or by means of electro-magnets, is adopted by the majority of the administrations dealt with in the report for the other countries and by one of those mentioned in the British report. The smokebox char is recovered separately, and in some cases is used for small suction gas plants, or as a fuel in the form of brickets or mixed with coal. In America,

however, no method of recovering or separating the coke is adopted.

Mr. Forte (in French). — We have arrived at the value of the saving effected by recovering coke from the ashes and I have a note on this point I wish to read:

« The amount of coke recovered from the ashes clinker, etc., may be as much as 15 % and 1.5 % of the coal burnt. The coke is sold or used in the works itself in place of coal and mixed and coal burnt in stationary boilers. The coke we recover can be valued at to two million lires. »

Mr. Renevey (in French). — I should like the American delegates to give us some information as to the minimum weight at which it becomes economical to instal mechanical appliances for emptying ashpits.

Mr. R. W. Bell. — At some of our larger terminals where we handle on an average 60 engines per day, we have a big pit filled with water, into which the ashes fall from the ashpans, and we handle those ashes by a locomotive crane equipped with a grab bucket. The crane swings and drops the ashes into a coal car. The ashes are used for filling in yards and for ballasting track on branch lines.

The President. — I think the question rather was as to the amount of ashes which are dealt with at a depot, and when it becomes desirable to instal mechanical plant of some sort or other. Obviously, if there is only a small quantity it will not be worth while.

Mr. R. W. Bell. — I will get to that in a moment. At the smaller stations where we handle on an average 20 engines per day, we handle the ashes with a bucket which operates on an inclined railway, either by electric or by air power, and this bucket, being filled with the ashes which fall from the ashpans is propelled up this incline and mechanically drops the ashes into a car. At still smaller stations where we have 10 to 12 engines, we shovel the ashes out of a dry pit up on to a car; but we find it more economical to handle our ashes, where we handle 25 engines or more, with some mechanical device.

Mr. Renevey (in French). — I propose that the number of engines being of little importance, no mention of number should be made in the summary.

The President. — That seems to be perhaps better. Then the recommendation would be merely a statement of fact: « The mechanical handling of ashes is recommended at the larger depots. »

— This was agreed to.

The President. — No. 3 is « Methods of cleaning tubes. »

3. — *Methods of cleaning tubes.* — For cleaning the ordinary small tubes, rods are still used, especially where it is necessary to remove incrustations of soot and cinders; however, the use of compressed air, or steam from an engine under pressure by means of a special jet, is stated to be extending. Similar devices are used to blow out large superheater flues, these being generally blown out from the firebox end.

Report No. 2 also mentions good results obtained by fixed steam jets provided inside the firebox which allow tubes to be blown through while running and rendering it unnecessary to clean these at the shed.

Mr. Vallantin, Paris-Lyons-Mediterranean Railway (in French). — I think my colleagues will be interested to hear of the test we have made on the Paris-Lyons-

Mediterranean Railway with the «Kylala» blast pipe. The use of this arrangement on ten engines has shown that the tubes no longer require cleaning.

Mr. Forte (in French). — Has there been any increase in coal consumption?

Mr. Vallantin (in French). — We have not noticed any increase of coal consumed by the engines in question.

Mr. Van Schouwenburg, Dutch India Railways Company. — I would like to mention the results which we have had with the same « Kylala » exhaust. We fitted two locomotives with the « Kylala » and two of the same type in the ordinary way, and have followed the results of those tests carefully. We could not find any difference either in the amount of fuel used nor in the maintenance of the locomotive, so there was no reason for the Company to continue the use of the « Kylala » blast pipe.

Mr. Weiss (in French). — Are all the engines about which Mr. Vallantin spoke superheated?

Mr. Vallantin. — Yes.

The President. — Does that apply to yours, Mr. Van Schouwenburg?

Mr. Van Schouwenburg. — Yes, they are all superheated.

The President. — You did not find any advantage in installing the « Kylala » apparatus?

Mr. Van Schouwenburg. — No. We had heard of the results which Mr. Vallantin has mentioned, and had hoped to find some improvement, but we could not.

Mr. Weiss (in French). — Was there no improvement in keeping the tubes clean?

Mr. Van Schouwenburg. — No, and as no advantages were stated we saw no reason to continue the use of this apparatus.

Mr. Forte (in French). — We have tested in Italy an apparatus consisting of tubes placed close to the side of the fire box and attached to the backplate. Those tubes project into the firebox and when it is desired to clean the smoke tubes throw a jet of steam against the tube plate. The tubes are thereby cleaned when stopping during a journey. One engine has been fitted and it has not been necessary to clean the tubes at the shed.

Mr. Pawlowski (in French). — Cleaning tubes by steam has the disadvantage that the atmosphere for some distance away is polluted. In Russia we had much trouble when we cleaned the tubes of oil-fired locomotives in this way.

The President. — Experience with special apparatus seems to have been somewhat varied and therefore it would be undesirable to make any definite statement upon that score, and I suggest that we delete all mention of cleaning tubes.

Now we come to No. 4 :

Cleaning locomotives : Besides ordinary hand cleaning with cotton waste and oil or other material, which is the method generally used, the American report mentions methods of mechanical cleaning consisting of washing with a mixture of warm water and oil applied by means of compressed air, especially for wheels and motion.

I do not know whether it is thought desirable that we should make some mention upon this head. Hand cleaning seems to be the general method used, but this American system is, I think, of growing importance, owing to the high cost of hand cleaning, and if it is successful it

may be worth while making some mention in our report of that method. Can you tell us, Mr. Bell, to what extent it is adopted in America?

Mr. R. W. Bell. — The general practice in America is to wipe the engines by hand with cotton waste and oil. Some roads have adopted a system of washing their engines down and wiping them in that manner with oil; they spray the oil on through a jet under air pressure, and then after it is sprayed on they wash it off with warm water. Then they do a certain amount of hand wiping after that, because the water does not seem to dry the engine thoroughly. I watched recently an engine being washed down on a certain railroad in the United States, and I will say that they did a very good job; the engine was very clean after it was washed with the oil and the hot water; but we have hesitated to go into that, because we were afraid of hot bearings. We were afraid of the dirt being washed down into the bearings. Making an analysis on one road which uses this intensively, as compared with our road handling a similar number of engines, during one month, we found that with our hand wiping and their washing with the oil and the water, we could do the job more cheaply than they could do it by 3 000 dollars during that month, and our engines presented a better appearance, I think, than their engines did. However, we are putting in a device of that description at a small terminal, and we propose to test it out very thoroughly, and if it is successful we may possibly extend it to other terminals; but just now we are of the opinion that we can do the job as cheaply with the hand wiping as we can with the oil and the hot water.

Mr. A. W. Bruce-Joy, Great Indian Peninsula Railway, British India. — Can Mr. Bell please let us know whether on that line which he has mentioned which used the special system of washing, there was any increase in the overheating of bearings?

Mr. R. W. Bell. — The people who had this system in use informed me that there was none; they had practically no more trouble with this system than they had with the hand wiping. It is all a question of cost, any way. We are handling so many engines during a month, and if we can wipe by hand as cheaply as we can with oil and water, I do not see any necessity for going to oil and water. Some roads, of course, operate very cheaply because they do very little wiping; other roads keep their engines in very good condition as far as cleanliness is concerned. The engines that I have seen over here are very very clean. (*Applause.*)

The President. — The only advantage of making any mention of locomotive cleaning would be if we could make a recommendation of some mechanical means of cleaning. If it is merely to say that cleaning is done by hand, I do not think it is worth saying. Therefore I suggest that we make no mention of engine cleaning in our report; this was agreed to.

Then we will go on to No. 5.

Water supply. — This includes, where necessary, pumping plant, reservoirs of such a capacity as to form periodical, temporary or permanent reserves, water columns suitably provided on the incoming or out-going roads from the shed, mains, standpipes, and other apparatus as a safeguard against fire, and all other accessories for the various requirements of the shed, workshop and staff.

The softening and purification of water

used for locomotive purposes is extending. This is done with the object of obtaining a better life from the boilers and a longer period in service of the tubes, with an economy of fuel and a reduction in the amount of washing out. Moreover, it allows local surface water to be used, even when this is of poor quality, instead of better water from a more distant source or which is less abundant or more expensive.

In this connection, Report No. 1 states that on some railways the results given by softening plants have not been, in the first place, sufficiently satisfactory for this process to be preferred to the treatment of water by means of chemicals introduced directly into the tender or into the boiler.

However, the author of this same report states that he cannot agree with this unfavourable opinion, and recommends, as do also the other two reports, the purification of water by decantation and filtration, or softening by chemical means by means of apparatus connected with the reservoir; these apparatus are now used on a large scale, and the American report gives detailed descriptions of these.

I do not gather from this résumé that a great deal of fresh information has come out as the result of the inquiry. The conclusions arrived at, as you see, are somewhat vague, and it will, I think, be difficult to arrive at any conclusions which would be of use to those who read the final report of these sittings.

Mr. Forte (in French). — I think that in this matter we should make a summary. These water softening plants are very useful as they reduce the scale deposited between two washings out. So far as upkeep is concerned the advantages of water softening cannot be denied, and I think we should say something upon it.

The President. — Is it generally accepted that the use of superheater locomotives has made the softening of water more important? Would it be useful to say : « The use of softening plant is increasing in all the countries dealt with »?

Mr. Renevey (in French). — We should make it clearer and add that in the countries where these softening plants have been gone in for properly good results have been obtained.

The President. — Then the paragraph would read as follows : « The use of water softening plants is increasing in all the countries dealt with in the reports, and good results have been obtained. »

— This was agreed to.

The President. — We will pass to No. 6 :

Turning locomotives. — This is generally done on turntables consisting of rigid girders balanced about a central pivot, or, in a more recent system, carried on three points of support.

It is to be recommended that the turntables should be of uniform type and of uniform diameter, and it is convenient to operate these by electric motors, or where this cannot be done, by other mechanical means. Mention is also made of a number of examples of triangular, star shaped, or circular tracks for turning engines, either in place of the turntables, or as an emergency measure should these be out of action.

The opinion of the Reporter and of Mr. Weiss — and I think I agree with it — is that, as there is nothing absolutely new in this recommendation, it might be suppressed altogether. Then we will make no mention of the turning of locomotives.

— This was agreed to.

The President. — The next is 7 :

ACCOMMODATION FOR THE STAFF. — a) *Dormitory.* — This consists of rooms with one or two beds and also includes lavatories and water closets.

b) *Baths, changing rooms and lavatories.* — There is a tendency to increase the amount of accommodation of this kind, regardless of expense, in the interests of the health and well being of the staff.

c) *Dining rooms and sitting rooms.* — The former, either with or without organised canteens, are provided in view of the increasing demand for better conditions. The latter, together with recreation rooms, on the other hand, have developed to a lesser extent, but have been provided in special cases and are included in the most recently constructed sheds.

This subject, I think, does not lend itself to a general recommendation. The circumstances of each shed have got to be considered on their merits, and suitable accommodation has got to be provided for the staff, but I doubt very much, subject to what you think, whether it is desirable to make a general recommendation.

Then we will not mention accommodation of staff.

That brings us to No. 8 :

Offices and other accommodations. — The former are provided for clerical work in connection with the control of the running shed, workshop and stores, or for technical and administrative purposes. The latter are used for instruction classes for the working engines foremen, as a pay office, for the caretaker, in connection with sanitation, for storing bicycles, or for other special purposes.

I think the same remarks apply there as apply to the accommodation for the staff.

Paragraph 9 is :

Heating apparatus, provision of hot water, illumination and telephone communication. — We have already examined this question as regards the shed itself. For the remainder, report No. 1 also states that the use of electric light with incandescent lamps is the most satisfactory and the most widely used, but it also quotes cases in which high pressure gas lighting is preferred.

Report No. 3 states that arc lamps are the best method of lighting large spaces in the open.

Report No. 2 recommends a central plant for providing hot water and heating the offices and buildings.

Here again I think there is nothing to draw special attention to.

Now we come to the question of running sheds for electric locomotives. My own feeling about this is that locomotive sheds as referred to this Congress was intended to deal with steam locomotive sheds. It seems to me impossible to deal with the question of electric locomotive sheds in a single paragraph. It ought to be dealt with perhaps by a paper of its own, and I think perhaps the better way would be to note that the conclusions arrived at refer exclusively to steam locomotive sheds, and to leave the question of electric locomotive sheds entirely outside the consideration of this meeting. I feel that we shall not be able to do it justice on the strength of a single paragraph.

Mr. Van Schouwenburg. — I should like to point out that Mr. Forte has mentioned copper welding in discussing the workshops, and I would ask if it would not be an important subject for a following Congress, to discuss the results of copper welding as well with acetylene as

electrically? It appears to give remarkable results.

The President. — We will take a note of that, at any rate, and it will be a suggestion which will be put forward for the consideration of the Permanent Commission. It has also been suggested that the question of sheds for electric locomotives might be also a matter for future consideration.

That I think concludes our business, Gentlemen, and I have to thank you very much for the attention which you have so kindly given to the business of this joint meeting.

Before we disperse, I have been asked to make an announcement with regard to the Morris track layer, in which many members of No. 1 section were interested. It is in use in Ireland, and Mr. Sides, the Chief Engineer of the Great Southern Railway, has said that if any member of this Congress desires further information with regard to this track layer, he will be pleased to give it. It is, as you know, an apparatus for taking up the old track and laying down the new entire, not piecemeal, but entire. Each length of rail with sleepers attached is taken up, and the new rails with sleepers attached are put down in its place. It is an admirable apparatus; I have seen it in use. If any member of this Congress desires to see it, Mr. Sides has said that he will be very pleased to welcome you in Ireland and give you a demonstration of the apparatus in use. I think most of you have had a print describing that apparatus, and Mr. Sides, who is a member of this Congress and with whom you can communicate here, will be very pleased to arrange a demonstration for you if you desire to see it.

— The meeting ended at 11.30 a. m.

DISCUSSION AT THE GENERAL MEETING

Meeting held on the 1 July 1925 (afternoon).

THE RIGHT HON. Sir EVELYN CECIL, VICE-PRESIDENT, IN THE CHAIR.
GENERAL SECRETARIES : Sir HENRY FOWLER and Mr. P. GHILAIN.

Sir Henry Fowler, *General Secretary*, read the final summary adopted by the 1st and 2nd sections meeting jointly.

This final summary gave rise to no comments.

The President. — The final summary is therefore as follows :

Final summary.

« 1. *Type of engine shed.* — Each type « of shed has its advantages, and the type « chosen is determined by local condi- « tions and the views of the railway con- « cerned.

« 2. *Pits.* — In some sheds all roads « are provided with pits.

« 3. *Recovery of oil and waste from « waste used for cleaning purposes.* — « In certain circumstances it has been « found advantageous to put down plant « for the recovery of oil and waste from « dirty waste.

« 4. *Arrangements for washing out and « refilling boilers.* — The use of hot « water for washing out and refilling « boilers can be recommended when « engines have to be kept at the shed for « the shortest possible time.

« 5. *Shed workshop.* — Generally « speaking, running sheds carry out all « repairs to their locomotives other than « heavy repairs, and maintain them in « good order. The extent of the repairs « to be carried out at the shed depends « upon local conditions.

« The repair shop should be able to « contain a reasonable proportion of the « engines stationed at the running shed, « and sufficient pits should be provided « for this number; some would be used « for inspection or changing wheels and « axles.

« Compressed air and oxy-acetylene « and electric welding are of great use at « a locomotive shed.

« 6. *Stores.* — Proper provision should « be made at each locomotive shed of the « following materials :

« *a*) Tools or equipment for temporary « issue or as a reserve stock;

« *b*) Spare parts or material;

« *c*) Oils;

« *d*) Various consumable stores for « use on locomotives and by the staff;

« 7. *Coal stage.* — The use of mechan- « ical coaling is increasing at the larger « sheds. Where soft coal is used there « is a loss owing to breakage, but this is « counterbalanced by the saving in cost « of labour.

« 8. The mechanical handling of ashes « is recommended at the large sheds.

« 9. The use of water-softening plants « is increasing in all countries dealt with « in the reports, and good results have « been obtained. »

— The General Meeting ratified this final summary.